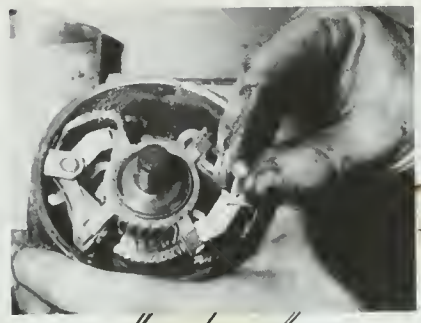
Science & Mechanics

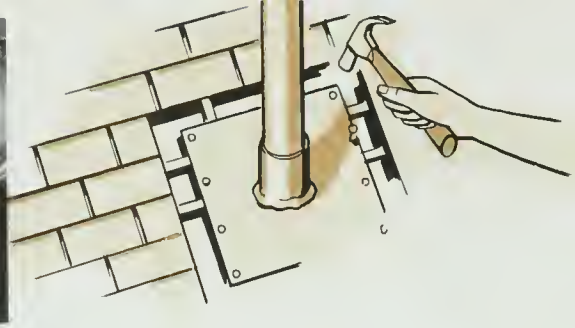
Complete HANDYMAN ENCYCLOPEDIA

do-it-yourself

ELECTRIC RANGE
FIRED AGO

Complete Handyman do-it-yourself Encyclopedia





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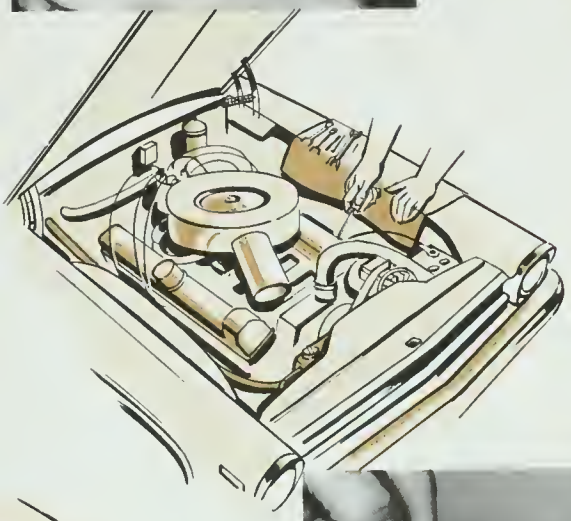

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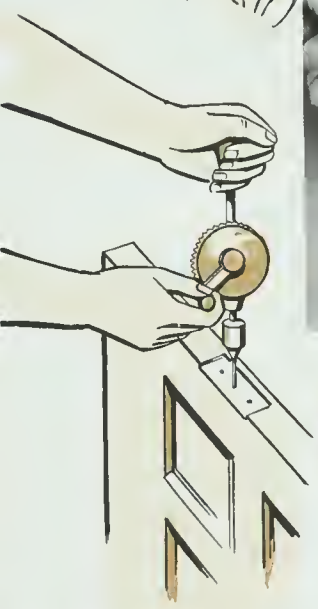

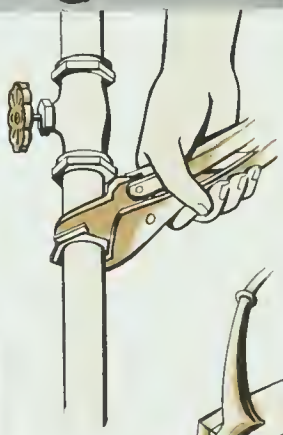

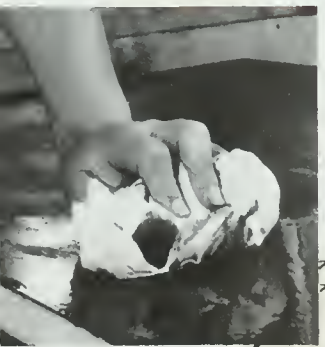

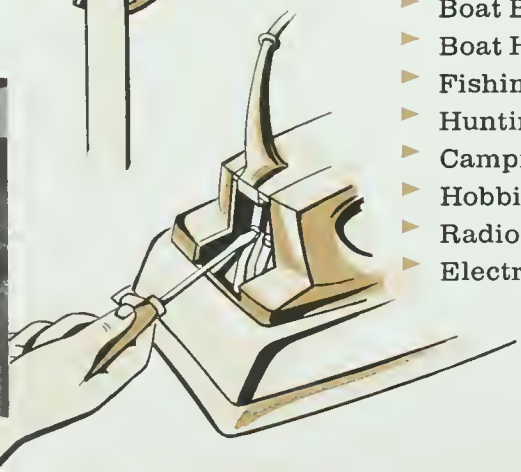

Complete Handyman yourself Encyclopedia

A COMPILATION OF SPECIAL INTEREST PROJECTS AND MANUALS FOR THE REPAIR AND CARE OF HOMES, AUTOS, APPLIANCES, HOBBY EQUIPMENT.

by the editors of

Science & Mechanics

7

ELECTRIC RANGE
FIREPLACE

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How to Repair Electric Ranges

The wiring diagrams look formidable, but don't let that deter you. The parts and individual circuits themselves are simple, so just take them one by one

SEVERAL ELECTRIC heater elements and their controls mounted on a frame or in a cabinet make up your electric range. The new models look more formidable every year, but each part and circuit is simple, so don't let their collective number throw you.

Before beginning any service work, look through your owner's manual carefully to make certain that you know what the range is supposed to do and assure yourself that it is being used properly. You should know, for example, that the oven door surface may rise to a temperature of 130°. While this is hot to the touch and may well be imagined to be higher, it is perfectly normal.

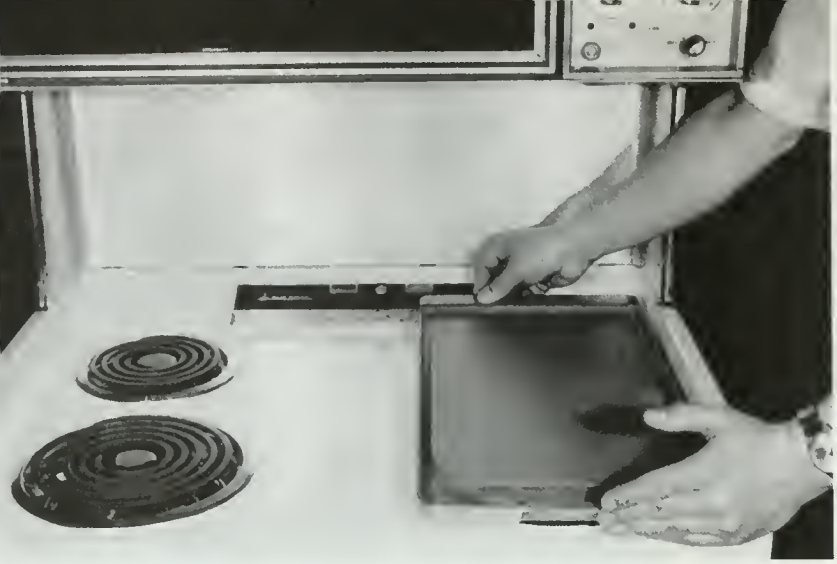
Ranges or stoves are usually connected to a 60-hertz, 230-volt, single phase three-wire circuit. Some metropolitan areas, however, have 208-volt current. Heater elements of 230 volts used on it may not heat sufficiently for satisfactory results. This is not a factor if your range has been operating satisfactorily, unless you plan to move. Heater elements can be changed to suit voltage requirements.

Voltage information is given on the model and serial number rating plate for your range and should be checked. You'll need these ratings and numbers when ordering parts or calling for a serviceman. Location of this plate varies according to make and model. Generally, it is accessible by lifting one of the surface units.

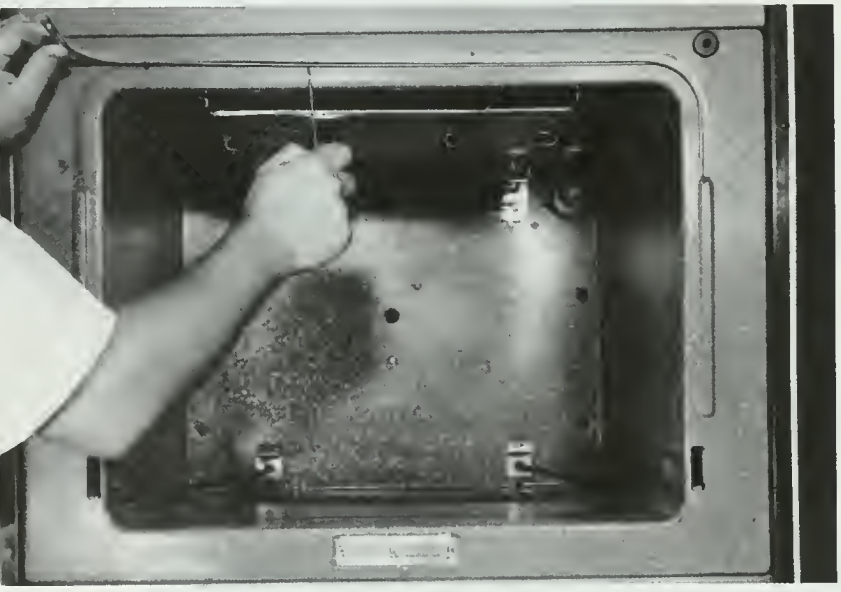
Oven adjustments. Are you getting lopsided cakes that are unevenly browned? This is due to your oven's not being level. Electric ranges depend on a very gentle flow of air to distribute heat evenly throughout the oven. Anything that disturbs this airflow will affect baking adversely. To check this, place a spirit level on the center oven rack for level indication. Check both "fore" and "aft" as well as "port" and "starboard." If necessary, adjust the leveling legs, which usually screw into the frame under the front corners of the range.

Your stove must be level, square, and

electric razor: see sharpening
electric water heater: see heating systems, home



The griddle of an electric stove is an aluminum plate with an electric heating element cast into it. The terminals are accessible from the underside and can be tested for continuity in the same manner as any other heating element.



Some range models have the oven door seal attached to the oven frame with spring clips. The seal can be replaced by gently prying the clips loose with a screwdriver.

stable for best results. Since any motion will affect use and any racking or warping of the frame will affect the oven door seal and closure, check the position periodically.

Door seal and fit. Foods will dry out in the oven and/or require excessive cooking time if the door does not seal properly. This may be due to a defective door seal or a warped or sprung door. Repair and replacement methods vary by manufacturer and model. If it looks like a complicated job and you start to develop a problem, don't do it! Your range might be different.

Some adjustment can be made if only one upper corner closes and the other doesn't; by adjusting the two flathead, oven door alignment screws located about 5 inches up and 5½ inches from each side of the oven door. They attach to a cross brace so that turning the right screw clockwise will apply pressure to the upper left panel, and vice versa.

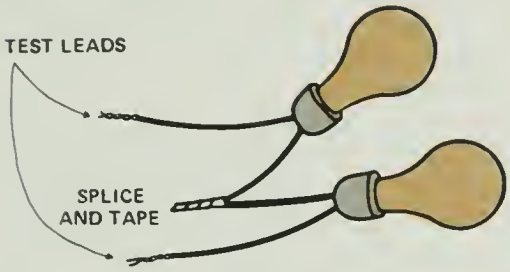
All ovens must have a vent to allow excess moisture to escape. A clogged vent will cause a damp oven, uneven browning, and excessive baking times. It's certainly to the cook's advantage to keep the oven vents reasonably clean. In most

TEST LIGHT OR VOLTMETER LEADS PLACED BETWEEN SWITCH TERMINALS

Switch Position	A		B	
	Light	Reading (volts)	Light	Reading (volts)
1	Bright	230	Bright	230
2	Out	0	Bright	230
3	Bright	230	Out	0
4	Dim	115	Dim	115
5	Out	0	Dim	115
6	Dim	115	Out	0
7	Out	55	Out	55

NOTE: Most test lights will not operate below 90 volts. In order to get an indication in this position, place light between terminals 1 and 2. This will indicate the sum of voltage or 110 volts on a meter and a 230-volt bulb will light dim.

Two 25-watt, 115-volt lamps connected in series make an effective test light for 220-volt circuits. To test 120-volt circuits, replace one lamp with a fuse.

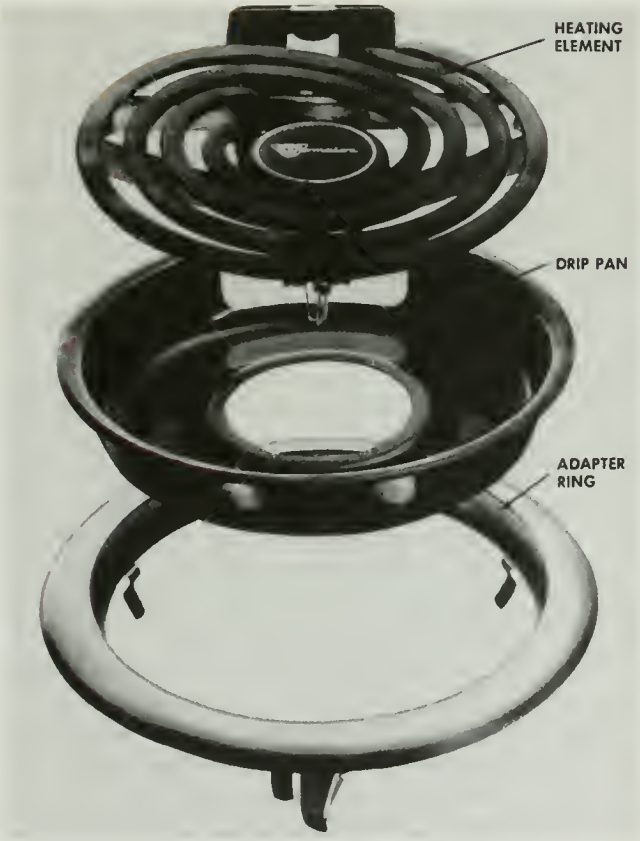


FUSE

ranges, the vent is under a rear surface unit above the oven.

Operational problems. A range has a resistance (heater element) and a control to regulate the flow of electricity to the heater. Each heater has its own control and wiring independent from the other's up to the connection to the supply line.

A supply line failure—blown main range fuse—will usually affect operation of all the cooking and baking elements to some extent. The easiest way to prove this is to



Replacement heater elements are available in two sizes—large and small—and come with adapter ring and drip pan. The two heating elements can be connected to a seven-heat switch or connected in parallel for use with an infinite heat control.

check from the ground or neutral (white wire) terminal to each of the two line terminals, with a test light.

Make certain that all swiches on the range are OFF or you may get a false reading. The voltage between the neutral and either line should be 115 volts, and from line to line, 230 volts. Be careful of what you touch and how you connect your test light, particularly if you are using a 115-volt bulb. If you do not have a 230-volt bulb, hook-up two 115-volt bulbs in series. This tester will also come in handy when checking voltage at the heater elements.

If correct voltage is supplied to the range and an element still does not heat up, check the heater elements. Each of these units, no matter how shaped, must indicate a continuous circuit when tested with a continuity tester. When using this device disconnect the element from the range to ensure a true reading. An open circuit or abnormally high resistance means the unit is defective and must be replaced. There is no repairing a defective rod or ring-type heater element.

A break in an open coil type of heater can be silver-soldered but this is a matter of judgment! Don't waste your time repairing an old, burned, sagging, or stretched-out element; it will only give you more trouble later. Also, don't lose more than three or four inches of straight resistance wire. If you do, the element will overheat and have a short life.

If the heater element in question checks OK and you know there is voltage to the range, the trouble must be in the wiring or control for that particular heater element. It is rare for the wiring itself to go bad, but check the terminals to make sure all are tight and connected. Trouble-shooting the controls, however, can get a little complex because of the variety in use.

Most controls are made by a few manufacturers that specialize in them, but are used by many different range manufacturers. It will be easier to describe the representative controls and what they do. Generally speaking, defective controls should be replaced. It is impractical to repair them.

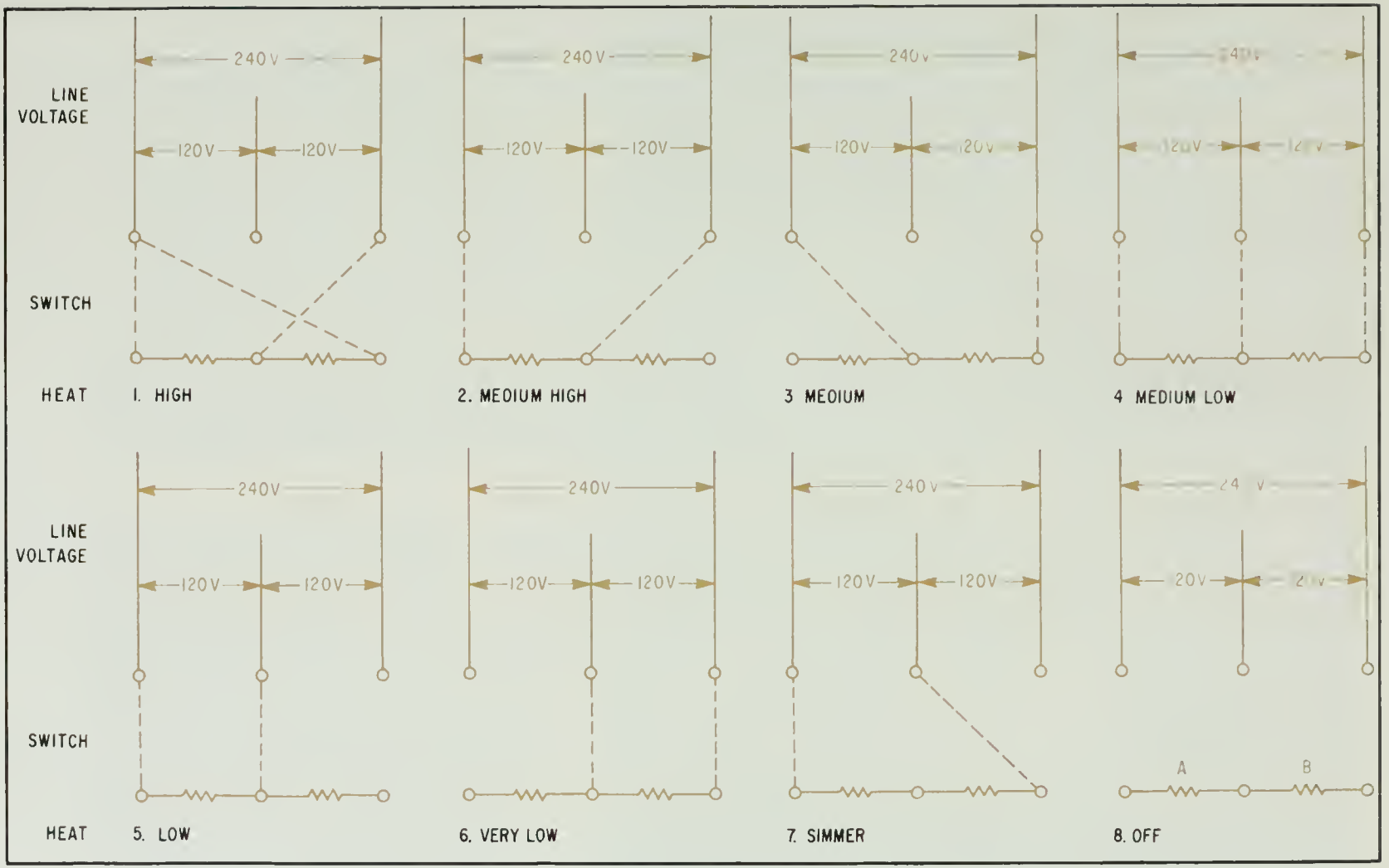
Surface unit controls. The eight-position (or seven-heat plus an "off" position) switch is one of the most commonly used controls with a two-section or three-terminal heater element. Such switches are physically interchangeable, but there are differences in their terminal connections. If you ever have to change one, watch your replacement wiring connections. These switches connect the line voltage in various combinations to the heater elements.

A 230-volt test light or voltmeter will indicate the different switch positions as shown in the accompanying chart which agrees with information from Kelvinator, Norge, Tappan, Whirlpool, and several other makes.

If the voltages listed are not present at the element when the correct voltages are applied to the switch and the wiring is correct you can assume that the switch has failed and should be replaced.

To replace a surface unit switch on a range, first disconnect the range from the electrical circuit. Then remove the top screws from the backguard trim panel. Now remove the screws from the sub-panel to expose all components in the backguard. Disconnect the wiring from the faulty switch and remove the switch mounting screws. The switch is now free. Reinstall a new switch in the reverse order. At the start it will be helpful to make a drawing or chart to show how the wiring should be replaced.

Oven-broiler controls. Don't condemn the oven or broiler controls for not working unless you are sure the automatic timer is set in the manual or non-automatic position. Check your owner's manual for the correct indication on your particular range.



With this switching arrangement, heater element A has a higher wattage (lower resistance) than heater element B. Only those heating elements connected to the line will have voltage and produce heat.

Many an unnecessary service call has been made because someone didn't check the timer position before calling for help.

Oven temperature is controlled by a thermostat which automatically turns the current to the oven element off and on. Its operation depends on the expansion and contraction of the fluid contained in a thermobulb located in the oven and connected to the thermostat by a tube. Expansion of this liquid due to heat will open the contacts, thereby shutting off the current. When the liquid cools, the contacts will close, allowing current to flow.

The location on the thermobulb should not be changed. This spot was chosen by the designers of your range to provide the most accurate control. Don't pinch, nick, or get sharp bends in the tube because this will adversely affect the flow of the control fluid.

If the oven does not heat, check for power to the thermostat and the element and for continuity of the heater element before touching the thermostat!

If you believe that the oven temperature calibration is not accurate, check it in the following manner:

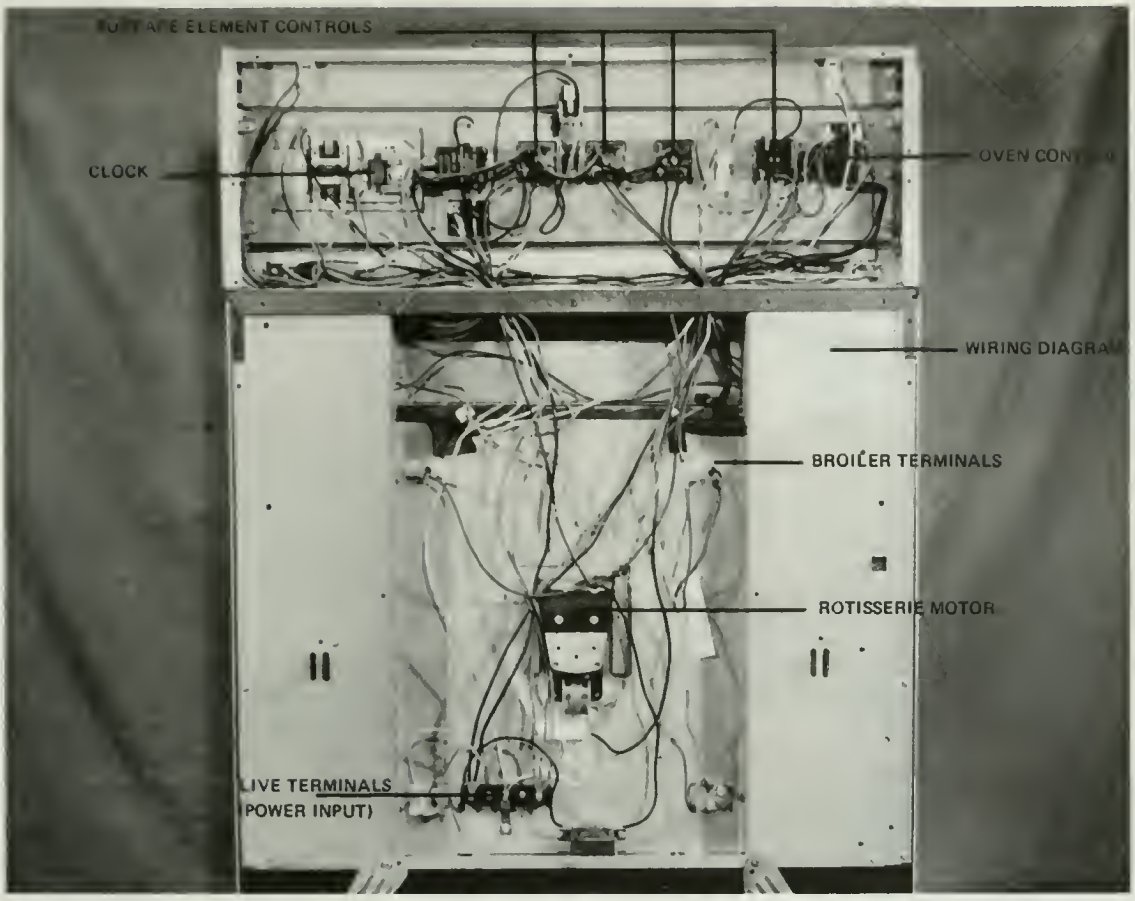
1. Place an oven-type thermometer (or another reliable temperature measuring device that will read as high as 400°) on an oven rack in the center of the oven.
2. Close the door.
3. Turn the thermostat dial to 350° and allow it to cycle at least two or three times (about 15 or 20 minutes).
4. Open the door and take a quick reading before the thermometer cools down. It should be within 20° of the dial setting. If not, the thermostat may need recalibrating.

Thermostat adjustment. Don't be too hasty to undertake this job. Make very sure everything else—door seal, vent, etc. —is in good condition first. There are many different types of controls in use and the method of recalibration will vary with the make used. Here are some:

Robertshaw oven thermostat, series N. Remove the thermostat dial by pulling it off; do not turn it. Loosen the two calibration screws about a turn. Hold the hub stationary and move the calibration plate by turning the thermostat shaft. Turn it clockwise if the temperature in the oven is above the dial setting; counterclockwise if oven temperature is below the dial setting. Spacing between calibration marks equal about 25° of oven temperature as marked on the dial. Tighten the two screws, push the dial back in place and recheck the oven temperature. Note that this calibration does not change oven temperature; it repositions the dial to agree with it.

Wilcolator oven thermostat, type B. Set the thermostat dial to the temperature read on the thermometer. Pull the dial off, do not turn it! Hold the dial support so that it will not rotate and loosen both Phillips head locking screws about a turn. Insert a #2 Phillips head screwdriver so that it meshes with the gear. Turn screwdriver clockwise to increase the oven temperature or counterclockwise to decrease it. Rotate screwdriver back and forth to cause "bake" pilot light to go "on" and "off," then set the screwdriver halfway between these two points. Hold the dial support and tighten the locking screws. Replace dial and recheck oven temperature.

The Chromalox infinite heat control switch has a bimetal blade wrapped with resistance wire. When current flows through this resistance the bimetal blade will bend, causing switch contact to open. As it cools, the switch contacts will close. Opening and closing of the switch contacts controls the flow of electricity to the heater element. Pressure on the contacts (length of time that they stay closed) is controlled by a cam connected to the switch dial.



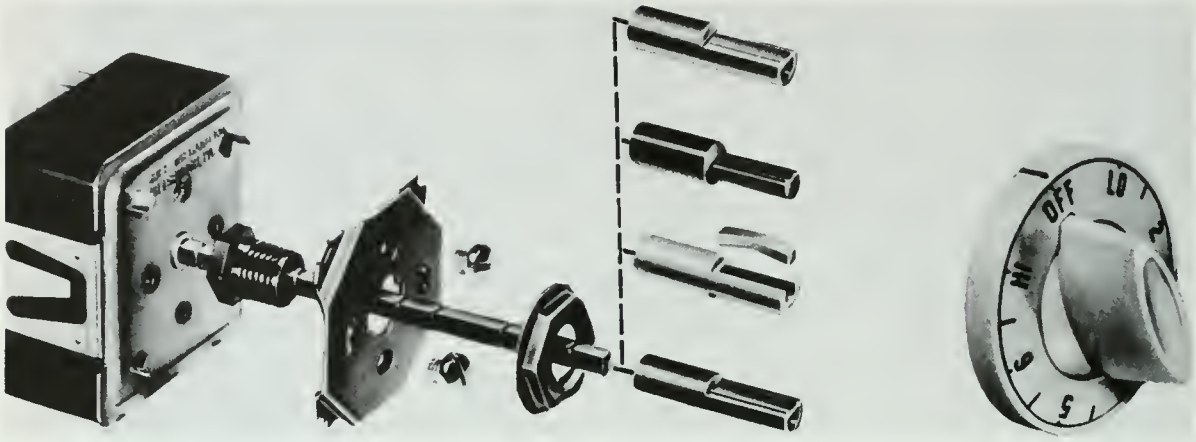
Removal of back panel will expose the wiring and control connections. Usually, the wiring diagram is pasted on the back.

To test the switch, connect your 230-volt test light to the heater element terminals and turn the switch "on." Full voltage must be available. If it is, and the element still doesn't heat, replace the element. If there is no voltage, but the wiring is good and voltage is available at the switch input, then replace the switch.

Surface unit thermostat. Top-unit thermostats, such as the King-Seeley type, are different in that they use a temperature sensitive wire to control the heat to the unit. This allows for accurate temperature regulation, but must be used correctly.

Before blaming the thermostat for poor temperature control, know that there must be good contact between the utensil being used and the control unit centered in the heating element. Remember that the control unit must be clean. Spilled or burned food will make poor contact between the control unit and your cooking utensil. The unit may have to be cleaned with steel wool.

Be sure that flat-bottomed utensils are used; that they cover the unit completely; that there is good heat conductivity from the heater, through the utensil bottom, to the control element.

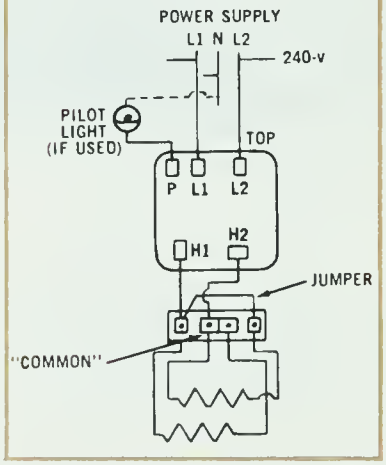


This is a universal electric range infinite heat replacement control. It can replace three-, five- and seven-heat controls or other infinite heat controls on most ranges.

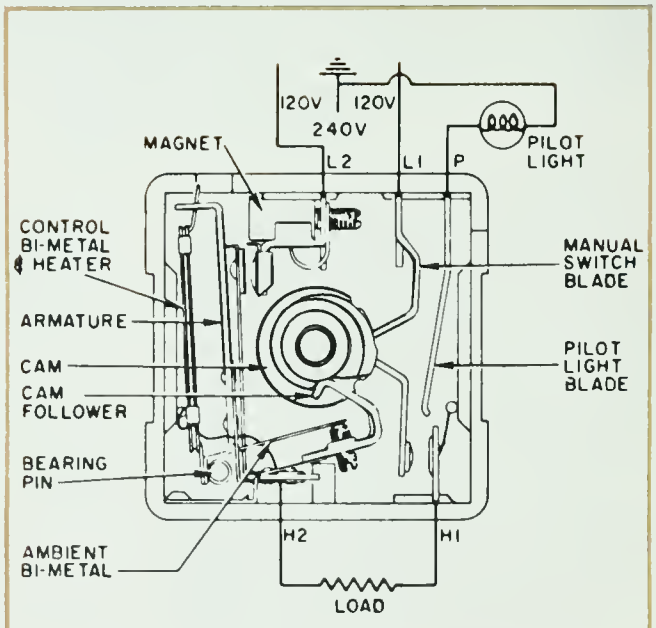
This type of control unit senses the temperature of the utensil bottom. The materials from which your cooking utensils are made will vary in heat conductivity and cooking time.

If you want to check the calibration of this control try the following: Place a three-quart pan containing a quart of water on the unit. Place a cooking thermometer or thermocouple in the water

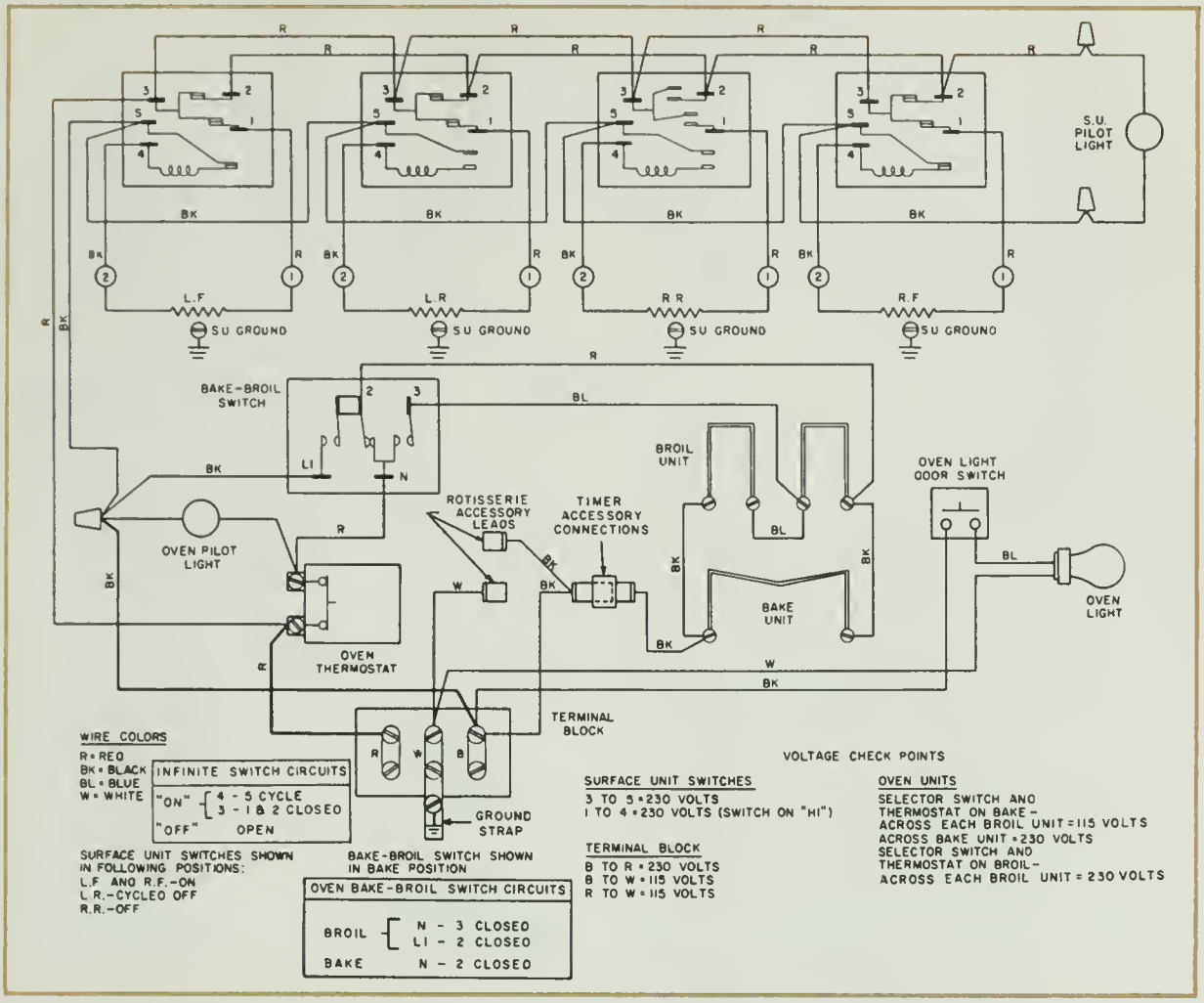
Replacing Infinite Control Switches used with 240-v Double Coil Element Surface Units.



The infinite heat control is being used universally to replace older switches. It comes with detailed installation instructions.



Components and Schematic of Infinite Control



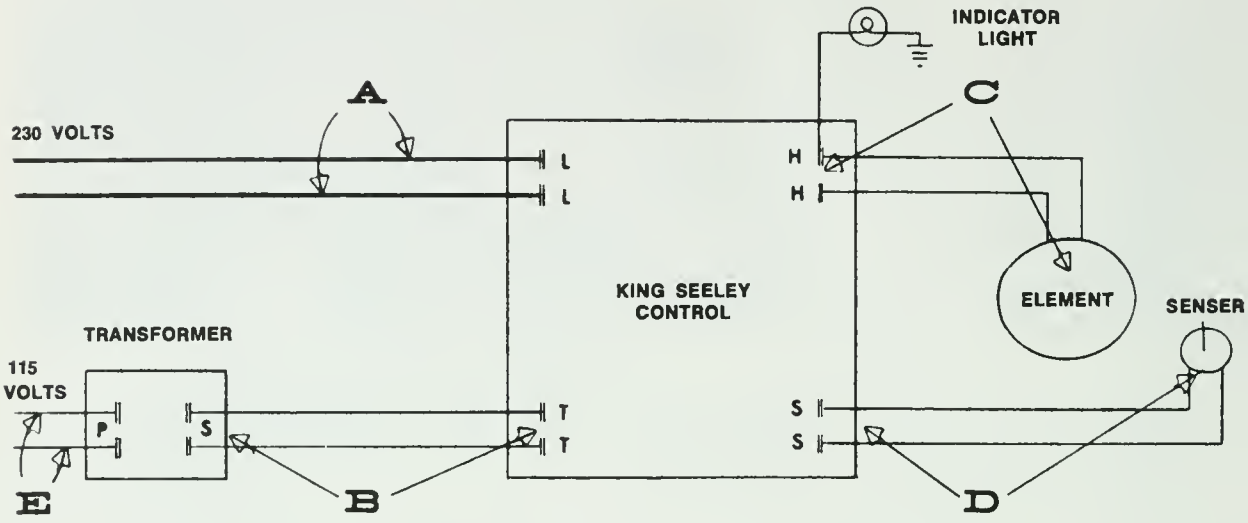
A typical electric range wiring diagram. The unit diagramed has infinite heat controls for the surface units. Other diagrams may appear more complex than this one, but each circuit must be tested as an individual unit. Remember, each heating element has its own control between it and the power input.

about ¼-inch from the bottom and within 1½ inches of the center. (The simplest way is to place a wadded rag on the pan bottom or set the thermometer in a cork which will "float" it slightly above the bottom of the pan. It must not touch the bottom of the utensil or the reading will be incorrect.)

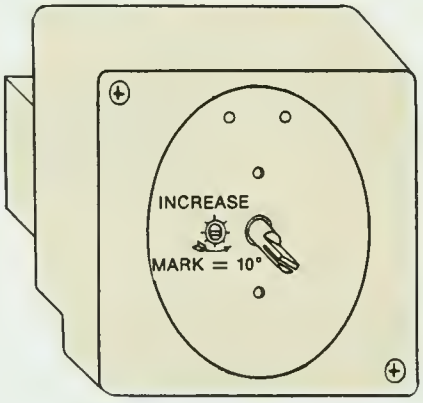
Cover the pan and turn the control dial to just below boiling. On some models the setting will be 200° on others it may be No. 3½. Allow the unit to operate 10 to 15 minutes to stabilize the temperature. The water should not be boiling! (If it does boil—recalibrate.) With the control set at No. 4 and allowed to heat for five minutes more the water should just start to boil (allow boil with bubbles just breaking the surface). At No. 4½ the water should boil.

Recalibrating top unit control. Remove the knob first, a step which varies from range to range. Remove only enough dials

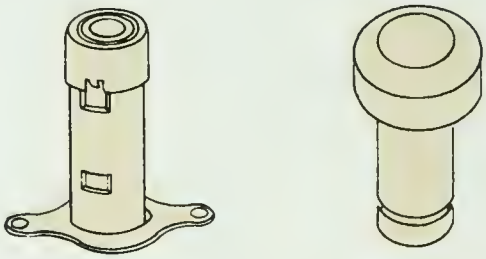
BLOCK DIAGRAM OF THE KING SEELY CIRCUIT



TERMINALS SHOWN ON COMPONENTS ARE NOT IN THE EXACT PHYSICAL LOCATION IN ORDER TO SIMPLIFY THE DIAGRAM.



CALIBRATION SCREW LOCATION FOR THE KING SEELEY CONTROL



SENSING ELEMENT IS MOUNTED IN THE CENTER OF THE BURNER AND MUST MAKE FIRM CONTACT WITH THE UTENSIL BEING USED.

The King Seeley control feeds the heating element a full 230 volts until the sensing element registers the desired temperature. Then, the unit cycles the current on and off to maintain that temperature.

or paneling as needed to expose the calibration screw.

The calibration adjustment screw is now accessible through $\frac{3}{16}$-inch hole between the control shaft and the left hand mounting screw. Turn the screw clockwise to decrease the temperature setting, counterclockwise to increase it. Each 30°

angular movement of the screw is equal to 10° of temperature. After recalibration always recheck the temperature of the unit.

The King-Seeley control applies the full 230 volts to the element every time it is turned on and at any dial setting until the temperature called for has been reached in the utensil. From then on, it cycles at that temperature.

If the heating element remains cold and your test light shows 230 volts at the element's terminals, then the element is defective and must be replaced.

If no voltage is available to the heater element and does appear at L1 and L2 (see drawing) at the control, then the trouble may be either in the control or the sensing element.

Unless you have a low-range AC voltmeter, now is a good time to stop and call in professional help!

To check out the transformer sensing element and its wiring, connect an AC voltmeter with a 15-volt scale across to two sensing element terminals. Do not remove the wires from the sensing element. This will damage the control.

Turn on the thermostat. A properly functioning sensing element will cause the voltmeter needle to move 10 volts, level off, then move back to the front of scale, and cycle back and forth. An open sensing element will cause the needle to go all the way to the edge of the scale. An open transformer will not deliver the required 12 volts AC.

The normal cold resistance of the sensing element is 11 ohms. If the sensing element and transformer check out, then the control is defective. Parts will have to be replaced—they cannot be repaired.

The accompanying chart is broad enough in scope to guide you in checking most electric models. Remember to use a 230-volt test light bulb. G.M.

See also: APPLIANCE REPAIR; ELECTRICITY.

ELECTRIC RANGE TROUBLE-SHOOTING GUIDE

PROBLEM / POSSIBLE CAUSE	BLOWN FUSE	LOOSE CONNECTION	FAULTY SWITCH	BROKEN WIRE	DEFECTIVE ELEMENT	NOT OPEN DURING PREHEAT	CLOGGED OVEN VENT	DEFECTIVE DOOR SEAL	BROKEN SPRING, HINGE PIN	SWITCH "OFF"	THERMOSTAT DEFECTIVE	TIMER INOPERATIVE
UNIT DOES NOT HEAT	√	√	√	√	√					√		
UNIT PARTIALLY HEATS					√						√	
OVEN SWEATS						√	√	√				
OVEN DOOR DROPS									√			
OVEN DOES NOT HEAT		√	√	√	√			√		√		√
OVEN TEMPERATURE INCORRECT											√	
OVEN DOES NOT TURN OFF											√	√

All about Microwave Ovens

Electronic cooking equipment has advantages such as speed and easy clean-up. But it's expensive. Get the facts on types, uses and kitchen locations before you make your decision

IS THERE a microwave oven in your future? If there is the slightest possibility that you will buy one of these modern cooking aids in the foreseeable future, you should plan toward that eventuality before you begin renovating your present kitchen or build a new one.

You may be perfectly happy right now with your conventional oven, and still be tempted to buy a microwave oven as an adjunct (*not* replacement) to your present cooking appliances. At least domestic and foreign oven manufacturers are betting heavily that you will.

Microwave ovens are expensive—currently available portable models start at about $400—so compare all brands and models carefully before making a selection. The first question that arises is whether to buy a portable or permanently located model. This is a highly personal consideration that only you can decide, bearing in mind the advantages and limitations of both types. For example, the stationary models are bigger and will take larger meats and other foods. On the other hand, a portable model might be used more because it can be moved to a dining room or even to the outside patio.

Even a portable oven is likely to be kept in the kitchen most of the time, so think about where it would be stored. If counter space is already less than adequate, explore the possibility of installing the oven

electronic flash: see photomicrography
electronic ignition: see ignition system, auto

in a roll-out section of kitchen cabinetry. In any case, try to find a location conducive to safe usage of the oven. Try to place it where those in the kitchen will not have to stand or sit too close to the oven when it is turned on. This means keeping it away from the sink area, for example.

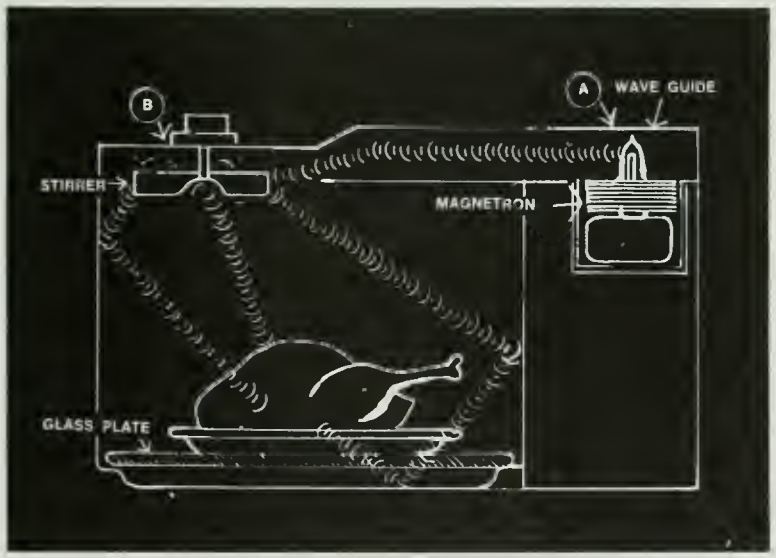
How microwaves cook. Perhaps the most fascinating thing about microwave cooking, aside from the amazing speed, is that the oven stays cold because the cooking heat is generated inside the food. Electronic gadgets inside the oven generate, not heat, but electromagnetic energy falling within the broad spectrum used for radar and certain communications applications. Most ovens operate at a frequency of 2450 MHz, although some 915 MHz units have also been made.

When these radio waves penetrate food, the food molecules become agitated and produce heat through molecular friction in a manner roughly analogous to the generation of heat by rubbing one's hands together. Although the food becomes hot, cookware holding the food remains quite cool to the touch. Plastic, paper and some types of glassware are ideal for microwave cooking because they transmit microwave energy; metal containers should not be used as they reflect, rather than transmit, energy.

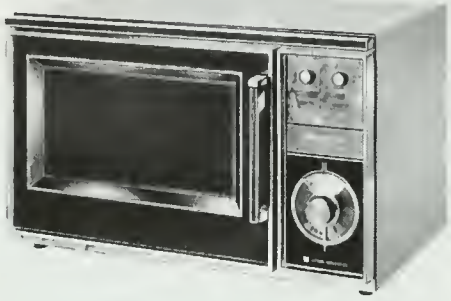
In most cases food will cook in about a quarter of the time required in a conventional oven. For example, a five-pound roast, which would cook in about two and a half hours in a regular oven, is done in less than forty minutes. A baked potato is ready in four minutes. Foods that have a high water content require longer cooking times. Many foods, especially vegetables, exhibit superior flavor when cooked electronically; their vitamin contents are also higher.

You will have to accept the fact that some foods will not look quite the way they are supposed to look. For example, pie crusts and meats (except very thick roasts) do not brown as they do in ordinary ovens. This means that you must brown the food in a conventional oven, or buy a microwave oven having a built-in browner (now offered only in stationary models).

Cooking power. Perhaps the simplest way to compare the cooking efficiencies of different brands and models of microwave ovens is to compare the manufactur-



Magnetron produces energy and the stirrer distributes it.



Minute Master electronic oven from Litton Industries. A similar model, the Galley Master, is made for use on pleasure craft.

ers' estimates of typical cooking times for like foods. A more scientific approach is to compare output wattages of the different units, taking care to note just what kinds of wattages are being quoted. A given oven may consume 1,100 watts of electrical power but it may put out only 600 watts of radio frequency (r.f.) power. *Cooking power* must be compared in terms of the r.f., not electrical, power.

Most available microwave ovens produce approximately 600 watts of r.f. power, though the actual range is from 575 watts to 750 watts. The higher wattages are likely to be found in the larger-sized ovens of stationary units.

Portable microwave ovens generally operate on 115 volts and draw about 14 amperes of current; this means that you can plug them into any conventional wall socket. The stationary units require 230-volt power supplies.

What size oven? It is quite obvious that if you are in the market for a combination unit that has a conventional oven and range as well as a microwave oven, you will have to study your kitchen layout carefully to see where it will fit best. But give some advance thought to locating a portable oven as well since it is likely to weigh around 80 or 90 pounds—too much to move about when a little more counter space is needed. You should not consider the portable unit as being "moveable when necessary" unless you can put it on a wheeled cart.

The external dimensions will determine where you will locate the oven; the internal ("cavity") dimensions will determine what you can cook in the oven. Stationary ovens are roomy enough to take large roasts and fowl, but you may find that portable units are too small for the larger meats and other bulky items.

The larger units offer about 1.26 to 1.44 cubic feet of cooking space while portables have only 0.6 to 1.0 cubic feet of space. In addition to comparing the cavity volumes in different brands and models, study the physical shapes of the different ovens. For example, two ovens having the same volume may differ significantly in shape; one may be much higher, while another may be wider. To be sure that you are getting an oven having the most convenient shape for your cooking purposes, make some measurements of the larger roasts and fowl that you are likely to want to cook, before you go shopping for an oven. If you spend $400 or more for an oven, be certain it will accept meats large enough to feed your family.

Are microwave ovens safe? Federal public health officials have become increasingly concerned about the potential radiation hazards posed by electronic devices used in homes. Consequently, microwave ovens are being studied intensively.

The *potential* radiation hazards of a microwave oven are not the same as those posed by color TV sets. Television sets produce X-rays which have an *accumulative* adverse effect on body tissues since they cause irreversible molecular damage within body cells. On the other hand, microwave radiation hazards are due to thermal effects which are not accumulative in the same sense; thus it is possible to establish a minimal threshold level below which no harm is likely. The microwave

The General Electric Versatronic model cooks food electronically or conventionally, or both ways at once, in its self-cleaning single-oven.

Tappan's Electronic Cooking Center combines the microwave oven with a conventional oven and range. The electronic oven has a 1.44 cubic foot capacity.

Built-in oven by Tappan provides electronic cooking in the upper section and conventional cooking in the lower, self-cleaning oven, which bakes away burned-on splatter.

radiation is most harmful to the eyes (which is why children should not be allowed to peer into the oven when it is in operation), and to the male reproductive organs.

The industry is giving considerable thought to making microwave ovens foolproof in terms of radiation leakage. For example, a good oven has two door interlock switches that cut off the power automatically when the door is opened; one of the switches is hidden to prevent the incautious owner from defeating the system when he wants to test the oven with the door open.

Another major problem is making the door seal so that hazardous amounts of radiation cannot escape. The highest degree of protection is said to be obtained when the door seal incorporates an electrical circuit—a so-called *choke seal.* Carbon-loaded vinyl strips are usually added to dampen or absorb any radiation that escapes the choke seal. Though you may not be particularly interested in these technicalities, it is well to bear in mind that ovens featuring a browning element (which produces heat in the normal way) precludes the use of the vinyl strips. Thus, in these and any other ovens not utilizing such sealing systems, the physical closure should be very good. Which is to say that if you see any open slits when the door is closed, send it back!

Actually, there may be very little to be concerned about, especially with ovens of recent manufacture by a reputable company. But since it is an unhappy truism that even among the best, defects can occur. Especially when equipment becomes old with use, it pays to add any reasonable safety factor. Thus it makes good sense to locate the oven where people are not likely to be near it for extended periods of time when it is operative. This does not mean that the oven has to be at the other end of the room away from all other work areas. The energy intensity falls off as the square of the distance increases thus leakage that might be dangerous to the eyes a few inches from the oven would be harmless an arms length away.

Guarantees. Some of the electronic components in a microwave oven are very expensive, so be sure that your oven carries a meaningful warranty that will be in effect at least two years, and covers both parts and labor. Since repairs will undoubtedly have to be made by the manufacturer's own service departments, find out where you would have to take or send the oven should repairs become necessary. In the case of permanently installed ovens, it is important to know how close the nearest authorized serviceman is located. If he is far from you, you may have to wait a long time for service during the warranty period; and after the warranty runs out, his services may be very expensive.

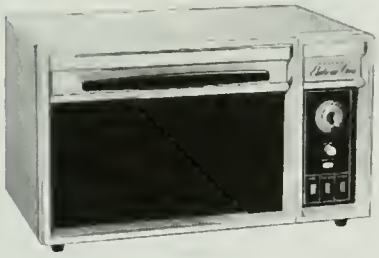
Japanese companies will be competing hard for U.S. microwave oven markets. In a way they are ahead of U.S. manufacturers because the microwave boom is already in full swing in Japan. Production in that country was probably close to the quarter-million unit mark in 1969, the volume anticipated for U.S. manufacture by 1975. The Japanese ovens (portable) will probably be among the lowest priced. Just be sure that adequate service comes with the attractive price tag. If in doubt, stick with the U.S. manufacturers since you can reach them more easily if problems should arise.

What's available? Because many companies are now getting into the microwave oven market, you have an opportunity to pick and choose among brands, styles and prices. Here are some of the makes already available:

Tappan offers three models. The top-priced model is a deluxe double unit that combines a microwave oven with a conven-

Toshiba portable microwave oven weighs 88 pounds, has 0.6 cubic feet of cooking space, and generates 600 watts of r.f. power.

The Amana Radarange can be installed in kitchen cabinets or walls with an optional "built-in" kit. Clean-up is no problem since oven walls are cool.



This build-it-yourself microwave oven is obtainable in kit form from the Heath Company and has 700 r.f. watts of cooking power.

tional oven and range. Sears & Roebuck also has a double oven and General Electric has come out with a similar unit. Thermador has an oven in this category as well as a single oven built-in model.

Getting down to the portables, you can have an Amana Radarange. Litton Industries makes a portable Minute Master electronic oven, and another called Galley Master which is intended for use on pleasure craft. Westinghouse has an "under $500" portable also. One low-price ready-to-use portable is Toshiba's unit.

Incidentally, while Litton Industries sells two models under its own label, the company also makes microwave ovens for sale under Montgomery Ward, Tappan and Admiral labels.

If you have an electronics kit builder in your family who may enjoy assembling a microwave oven, a complete kit, including all assembly instructions, is now available. What would you get for your money besides extra work? For one thing, an oven that is substantially larger than is available ready-made in its price range. On model offers about 0.92 cubic feet of space while the identically-priced ready-made Toshiba gives you only 0.6 cubic feet. Most other higher-priced portables have somewhat larger ovens: Amana, 1.03 cubic feet; Sharp, 0.95; Litton, 0.91; Roper 1.0; Westinghouse, 1.03 cubic feet.

As was noted before, to get a truly large size electronic oven, you have to think in terms of a double unit such as the G.E. combination unit having a 1.43 cubic foot microwave oven, or the Tappan model with a 1.44 cubic foot oven. J.H.

WHERE TO FIND IT

A complete microwave oven kit, including all assembly instructions, is available from the Heath Company, Benton Harbor, Michigan, or from local Heath stores.

The Practical Language of Electronics

Before you open the back of your TV set, it is important to learn the meanings of electronic prefixes and how they can be calculated

ANYONE WHO WANTS to be proficient in electronics will have to develop skill in understanding and using the prefixes here—*micro-, milli-, mega-* and *kilo-*—an important part of the electronic vocabulary.

These prefixes are used to change the value of an electronic unit of measure. For example, if you see a resistor with the familiar brown/black/green color code, you could call it a 1,000,000 ohm resistor. But it is usually less awkward to call it a 1-megohm resistor. Putting the prefix *meg-*or *mega-* before the ohm inflates the value of the unit ohm by 1,000,000 times.

Similarly, one kilovolt is recognizable as 1,000 volts and one kilohertz as 1,000 hertz, and so on.

At the other end of the scale, the *milli-* and *micro-* prefixes are useful for shrinking units. A farad, for example, is too big a unit to use in everyday electronics. In dealing with the real-life capacitors (the kind you solder into circuits), we normally use a basic unit of one-millionth of a farad—a microfarad. The prefix micro- cuts up a unit into a million tiny slices, enabling us to use one such slice as a convenient-sized unit. A microampere, similarly, is a millionth of an ampere.

If you need larger slices, the milli- prefix is available, which provides a unit only one-thousandth the size of the basic unit. A milliampere, for example, is a thousandth of an ampere; that is, it takes 1000 ma (milliamperes) to equal 1 ampere.

To handle these tiny slices of units, it is wise to spend a few minutes learning scientific notation, which is designed to make it easy to handle very large and very small numbers. Once you have mastered this technique, you can manipulate all the various-sized units of electronics as easily as you can add two and two.

Take, for example, the familiar kilohertz, (known until recently as the kilocycle). A broadcasting station operating at 840 kHz (kilohertz) in the broadcasting band is radiating 840,000 cycles of rf energy every second. To change from 840 kHz to 840,000 Hz, think of the "kilo-" as being replaced by "x 1000," thus:

840	kilo	hertz
840	x 1000	hertz
840,000		hertz

But you can also write "1000" as "10x 10x10." And you can write "10x10x10" as 10^3." (Ten to the third power, or ten cubed.) As we develop these ideas further, you will see how you can simplify greatly your future work in electronics by thinking of the prefix "kilo-" as being replaceable by "x 10^3," thus:

840 kilohertz = 840 x 10^3 hertz

Similarly, a 6.8 megohm resistor, measured on an ohmmeter, will indicate 6,800,000 ohms. In this case, the prefix "meg-" can be replaced by "x 1,000,000":

6.8	meg	ohms
6.8	x 1,000,000	ohms
6,800,000		ohms

But you can write "1,000,000" as "10x 10x10x10x10x10" which is 10^6. Thus, you should learn to mentally replace "meg-" with "x 10^6," so that 6.8 megohms becomes a 6.8 X 10^6 ohms. The 6 is called an exponent, and shows how many 10s are multiplied together.

elegant coffee table: see tables

What about the milli- and micro- prefixes? Milli- is one-thousandth; in a way, it is the opposite of the kilo- prefix. Make a mental note, then, that milli- can be replaced with "10^{-3}" (read as "ten to the *minus* three power"), which is 1/10x1/10x 1/10 = 1/1000. Similarly, the micro- prefix can be considered as the opposite of meg-, and replaced by 10^{-6}.

When faced with a practical problem, such as, "if 1.2 milliamperes flows through 3.3 megohms, what voltage appears across the resistor?" From our knowledge of Ohm's law, we know that E = IR; that is, to get Volts (E) we multiply current (I) times resistance (R). Without the aid of scientific notation, the problem is to multiply 0.0012 amperes by 3,300,000 ohms, which is rather awkward to carry out. The same problem, however, is very easy in scientific notation:

$$\begin{array}{r} 1.2 \quad \text{X} \quad 10^{-3} \\ 3.3 \quad \text{X} \quad 10^{6} \\ \hline 3.96 \quad \text{X} \quad 10^{3} \end{array}$$

The answer is 3.96 X 10^3 volts, or 3.96 kilovolts. We obtained the answer by multiplying 1.2 x 3.3 to get 3.96, and adding the -3 exponent to the 6 exponent to get 3 for the exponent of the answer. The advantage of scientific notation is that the largeness and smallness of the numbers involved is indicated by numbers like 10^6 and 10^{-3}, and the largeness or smallness of the answer is found by *adding* the 6 and the -3.

What about a division problem? For the sake of a good illustrative example, consider the unlikely problem of finding the current when 4.8 megavolts is applied across 2 kilohms. The problem is written:

$$I = \frac{E}{R}$$

$$\frac{4.8 \text{ megavolts}}{2 \text{ kilohms}} \qquad \frac{4.8 \times 10^6 \text{ volts}}{2.0 \times 10^3 \text{ ohms}}$$

$$4.8 \div 2 = 2.4$$

$$2.4 \times 10^3 \text{ amperes} = 2.4 \text{ kiloamperes}$$

In division, then, finding the size of the answer becomes a *subtraction* problem, in which the exponent representing the size of the divisor (bottom number) is subtracted from the exponent representing the size of the dividend (top number).

A practical division problem answers the question, "what current flows when 5 volts is applied across 2.5 kilohms?"

$$\begin{aligned} 1 = \frac{E}{R} &= \frac{5 \text{ volts}}{2.5 \text{ kilohms}} \\ &= \frac{5.0 \times 10^0}{2.5 \times 10^3} \\ &= \frac{5.0 \times 10^{(0-3)}}{2.5} \\ &= 2.0 \times 10^{-3} \text{ amperes} \\ &= 2.0 \text{ milliamperes} \end{aligned}$$

Note that it's perfectly legal to use 10^0 (ten to the zero power) to indicate a unit that has no prefix—in other words, one of anything.

Here are a few more problems:

1. Inductive reactance of a coil is given

$$X_L = 2\pi fL.$$

What is the reactance of a coil whose inductance L = 22 millihenries, when an alternating current of frequency f= 1.5 megahertz is applied to it?

$$\begin{aligned} X_L &= 2 \times \pi \times (1.5 \times 10^6) \times (22 \times 10^{-3}) \\ &= 207.24 \times 10^3 \text{ ohms} \\ &= 207.24 \text{ kilohms} \end{aligned}$$

2. An oscillator is connected to a wave length-measuring apparatus, and the wave length of its oscillations determined to be 2.1 meters. What is the frequency of the oscillator?

$$\begin{aligned} F &= \frac{\text{speed of light}}{\text{wavelength}} \\ &= \frac{3.0 \times \times 10^8 \text{ meters per second}}{\text{wavelength}} \\ &= \frac{3.0 \times 10^8}{2.1 \times 10^0} = 1.4286 \times 10^8 \text{ hertz} \end{aligned}$$

We wish this answer had come out with a "10^6," instead of a "10^8," because we can convert 10^6 hertz directly to megahertz.

However, we can change the answer to 10^6, by shifting the decimal point of the 1.4286. Remember this rule: To *lower* the exponent, shift the decimal point to the *right*. (Of course, the opposite rule is also true.) Since we wish to lower the exponent by 2 we must shift the decimal point to the right by two places:

142.86×10^6 hertz = 142.86 megahertz

3. A 3.3 microfarad capacitor is being charged from a 20-volt battery through a 6.8 kilohm resistor. It charges to half the battery voltage in a time given by

$$T = 0.69RC$$

For the particular values given in the problem, what is the time taken to charge to half the battery voltage?

$T = 0.69 \times (6.8 \times 10^3) \times (3.3 \times 10^6)$
= 15.4 milliseconds

Since scientific notation is so potent, you'll probably be interested in the meaning of all the prefixes used in the scientific community, not just the four—micro-, mili-, kilo-, and mega- —that we've discussed so far. Very common in electronics is the *micromicrofarad,* which is $10^{-6} \times 10^{-6}$ farad, or 10^{-12} farad. This is more commonly known as the *picofarad.* Similarly, a thousandth of a microampere is $10^3 \times 10^{-6}$ ampere, or 10^9 ampere. This is known as a nanoampere. At the other extreme, 1000 megahertz is called a gigahertz.

The jargon of electronics which has grown up around these prefixes is just as important as the prefixes themsleves. Here are some examples of "jargonized" prefixes:

Puff—a picofarad
Mickey-mike — a micromicrofarad
Meg—a megohm
Mill—a milliampere
Megger—device to measure megohms
db (pronounced "dee-bee")—a decibel
Mike—a microfarad

If you understand the prefixes and know their corresponding exponents, you will have a set of important tools to help you do practical work in electronics. N.C.

See also: COLOR TELEVISION; CITIZEN'S BAND RADIO; STEREO; TELEVISION REPAIR.

Prefix	Pronunciation	Symbol	Exponent	Example
tera-	TEHR-uh	T	10^{12}	Frequency of infra red light is approx. 1 terahertz
giga-	JIG-uh	G	10^9	Frequency of TV channel 82 is approx. 1 gigahertz
mega-	MEG-uh	M	10^6	Frequency of typical shortwave broadcast station is approx. 1 megahertz
kilo-	KILL-oh	k	10^3	Top note on a piano is approx. 4 kilohertz
deci-	DESS-ih	d	10^{-1}	A decibel is 1/10 of a bel
centi-	SENT-ih	c	10^{-2}	Wavelength of TV channel 82 is approx. 30 centimeters
milli-	MILL-ih	m	10^{-3}	Collector current of a typical small transistor is approx. 1 milliampere
micro-	MY-kroh	μ	10^{-6}	Base current of a typical small transistor is approx. 20 microamperes
nano-	NAN-oh	n	10^{-9}	Time for a radio wave to travel 1 foot is approx. 1 nanosecond
pico-	PY-koh	p	10^{-12}	Collector-to-base capacity of a good high-frequency transistor is approx. 1 picofarad
femto-	FEM-toh	f	10^{-15}	Resistance of 6 microinches of 0000 gauge wire is approx. 1 femtohm
atto-	AT-toh	a	10^{-18}	6 electrons per second is 1 attoampere

The Gem of the Electronics World

How a tiny crystal is constantly working to keep your radio on the station you want

CAN YOU IMAGINE the chaos on the AM broadcast band if transmitters drifted as much as those inexpensive table radios? The broadcast station engineer must keep the station carrier within 20 hertz of its assigned frequency. How is it done? What about the CB'er unable to contact the base station with an unstable, super-regen walkie-talkie. Lost calls do not often happen to a CB'er who can keep the receiver frequency on the assigned channel center.

This and much more is, of course, all done with a little help from a very basic material—the quartz crystal. It is the single component that serves to fill a basic requirement for precision frequency control. Quartz crystals not only fix the frequency of radio transmitters (from CB installations to multi-kilowatt-broadcast installations), but also establish the frequency of timing pulses in many modern computers. In addition, they can provide the exceptional selectivity required to generate and receive single-sideband signals in today's crowded radio spectrum. Yet this list merely touches upon the many uses of quartz crystals.

A real gem. This quiet controller is a substance surrounded by paradox. While quartz composes more than a third of the earth's crust, it was one of the three most strategic minerals during World War II. And despite its plenitude, several semi-precious gems (including agate and onyx) are composed only of quartz.

Unfortunately, quartz exercises its control in only a relative manner. When it is misused, the control can easily be lost. For this reason, if you use it in any way—either in your CB rig, your ham station, or your SWL receiver—you should become acquainted with the way this quiet controller functions. Only then can you be sure of obtaining its maximum benefits.

What is it? One of the best starting points for a study of quartz crystals is to examine quartz itself. The mineral, silicon dioxide (SiO_2), occurs in two broad groups of mineral forms: crystalline and non-crystalline. Only the large crystalline form of quartz is of use is a controller.

The crystalline group has many varieties, one of which is common sand. The variety which is used for control, however, is a large, single crystal, usually six-sided. The leading source of this type of quartz is Brazil. However, it also is found in Arkansas.

A property of crystalline quartz, the one which makes it of special use for control, is known as *piezoelectricity*. Many other crystals, both natural and synthetic, also have this property. However, none of them also have the hardness of quartz. To see why hardness and the piezoelectric property, when combined, make quartz so important, we must take a slight detour and briefly examine the idea of resonance and resonators.

Resonators and resonance. As physicists

developed the science of radio (the basis for modern electronics), they borrowed the acoustic notion of resonance and applied it to electrical circuits where it shapes electrical waves in a manner similar to an acoustic resonator. For instance, both coils and capacitors store energy and can be connected as a resonator.

Pendulum demonstrates. The principle involved is identical to that of a pendulum, which is itself a resonator closely similar in operation to our quartz crystals. To try it you can hang a pendulum of any arbitrary length, start it swinging, then time its *period*—one complete swing or cycle. The number of such swings accomplished in exactly one second on the *natural* or *resonant* frequency of the pendulum is cycles per second (hertz).

You can, by experiment, prove that the frequency at which the pendulum swings or oscillates is determined by the length of the pendulum. The shorter the pendulum, the faster it swings (the greater the frequency). The weight of the pendulum has no effect on frequency, but has a marked effect upon the length of time the pendulum will swing after a single initial push—the heavier the pendulum, the greater the number of cycles.

Once the pendulum begins to swing, very little effort is required to keep it swinging. Only a tiny push is needed each cycle, provided that the push is always applied just as the pendulum begins to move away from the pushing point. If the push is given too soon, it will interfere with the swinging and actually cause the swing to stop sooner than it would without added energy; while if too late, added push will have virtually no effect at all. It is this principle—a tiny push at exactly the right time interval—which makes a resonator sustain sound or AC waves. You can prove it with the pendulum by first determining the resonant frequency of a pendulum, then stopping it so that it is completely still. A series of small pushes, delivered at the natural resonant frequency (each too tiny to have more than a minute effect), will very rapidly cause the pendulum to swing to its full arc again. Pushes of the same strength at any other frequency will have little or no effect.

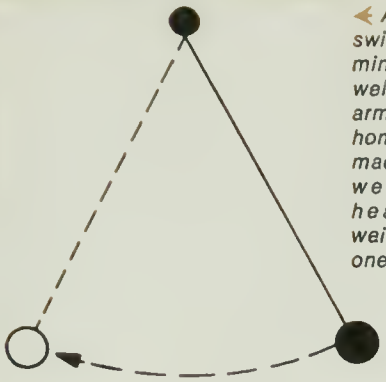
The pendulum is an excellent control mechanism for regulating a clock to keep time to the second, since the resonant frequency of the pendulum can readily be adjusted to be precisely one cycle per second. However, for control of audio frequencies from tens of hertz (cycles per second) up to tens of thousands of cycles per second (kilohertz), or for radio frequencies ranging up to hundreds of millions of cycles per second (megahertz), the pendulum is too cumbersome a device.

The tuning fork. In the audio range, the equivalent of the pendulum is the tuning fork. This is an extremely elongated U-shaped piece of metal, usually with a small handle at the base. When struck, it emits a single musical tone.

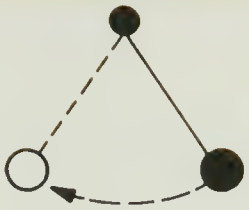
The operating principle is exactly the same as the pendulum. Each of the arms or tines of the fork corresponds to a pendulum arm. But here the arms are extremely short and much heavier in proportion to their size than the pendulum. (The shorter the arms of a tuning fork, the higher the resonant frequency in the audio range.) This greatly increased mass causes them to oscillate much longer when struck.

Not all tuning forks operate precisely like pendulums. The pendulum principle is based on a *flexing* of the arm upon its long dimension. While this is the most common operation, the fork may flex along any dimension.

It is even possible for a single, solid resonator, such as a tuning fork, to flex along several dimensions at once. A main part of the design of a good tuning fork is to insure that only a single dimension flexes or, in the language of resonators, only a single mode is excited.

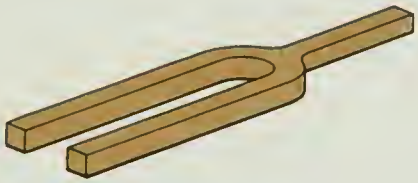


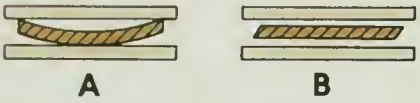
A long pendulum swings at a rate determined by its length and weight at the end of the arm. To experiment at home, the arm should be made of light thread (no weight) and a small heavy mass (all the weight concentrated at one point).



A short pendulum swings at a faster rate no matter what the weight is. The heavier the weight, the longer the pendulum will swing at the faster rate.

The geometry of the tuning fork produces a continuous pure tone for a long period when struck gently. It is favored by piano tuners as a convenient way to carry a source of accurately-known tone or pitch.





Depending on how the crystal is cut or sliced from the mother crystal, some crystals warp or bend as in A and others shear as shown in B. Each of the many cuts have special characteristics.

Area too. There is no requirement that the resonator be a completely solid substance. A mass of air, suitably enclosed, forms a resonator. This is the resonator that works on a classic guitar or violin. Here, single-mode operation is distinctly not desired. Instead, multiple-mode operation is encouraged so that all musical tones within the range of the instrument will be reinforced equally.

Now, with the principles of resonance firmly established, we can return to the quartz crystal and its operation.

Quartz crystals as resonators. Like the tuning fork or, for that matter, any sufficiently hard object, the quartz crystal is capable of oscillation when struck physically or in some other way excited.

But unlike the tuning fork, or indeed any other object except for certain extremely recent synthetic materials, the quartz crystal is not only sufficiently hard to oscillate at one or more resonant frequences, but is piezoelectric.

Piezoelectricity. The piezoelectric property means that the crystal generates an electric voltage when physically stressed or, on the other hand, will be physically deformed when subjected to a voltage. Other familiar objects making use of piezoelectricity include crystal and ceramic microphone elements and phonograph cartridges.

This virtually unique combination of properties (sufficient hardness for oscillation and piezoelectricity) found in quartz crystals, makes it possible to provide the initial push to the crystal by impressing a voltage across it. To provide the subsequent regular pushes, a voltage can be applied at appropriate instants.

Quality factor. Almost any discussion of resonance and resonant circuits (inductance) eventually gets to a rather sticky

subject labelled in the earliest days of radio, *quality factor* but now known universally as *Q*.

As used in radio and electronics, *Q* is usually defined by other means. Some of the definitions put forth include: The ratio of resistance to reactance in a coil; the ratio of capacitive reactance in a resonant circuit to the load resistance; the impedance multiplication factor; and others even more confusingly worded.

All, however, come out in the end to be indentical to the definitions cited above: The *Q* of a resonator is the ratio of the energy stored per cycle to the energy lost per cycle.

In a resonator, high *Q* is desirable. *Q* is a measure of this energy loss. The less energy lost, the greater the *Q* of the circuit.

Not so obvious (and rather difficult to prove without going into mathematics) are some of the other effects of *Q*. A resonant circuit is never completely selective; frequencies which are near resonance but not precisely equal to the resonant frequency also pass through!

The greater the *Q*, the narrower the band of frequencies which can affect the resonator. Specifically, the so-called half-power bandwidth of a resonator (that band in which signals are passed with half or more of the power possessed by signals at the exact resonant frequency) is expressible by the fraction *Fo*/*Q*, where *Fo* is the resonant frequency and *Q* is the circuit. Thus a 455 kHz resonant circuit with a *Q* of 100 will have a half-power bandwidth of 455/100 kHz, or 4.55 kHz. This relation is an approximation valid only for single-tuned circuits; more complex circuits are beyond this basic discussion.

The Q of quartz crystals. When we talk of the *Q* of conventional resonant circuits composed of coils and capacitors, a figure of 100 is usually taken as denoting very good performance and *Q* values above 300 are generally considered to be very rare.

The *Q* of a quartz crystal, however, is much higher. Values from 25,000 to 50,000 are not unheard of.

The extremely high *Q* makes the crystal a much more selective resonator than can be achieved with L-C circuitry. At 455 kHz, for example, the bandwidth will be between 10 and 20 hertz *(cycles* per second), unless measures are taken to reduce *Q*. Even in practice (which almost never agrees with theory), 50-hertz bandwidths are common with 455-kHz crystal filters.

As far as external circuitry is concerned, the crystal appears to be exactly the same as an L-C resonant circuit except for its phenomenal *Q* value.

At series resonance, the crystal has very low impedance. You may hear this effect referred to as a *zero* of the crystal. At parallel resonance, impedance is very high; this is sometimes called a *pole*. The special kind of crystal filter known as a half-lattice circuit matches the pole of one crystal against the zero of another, to produce a passband capable of splitting one sideband from a radio signal. Such filters are widely used in ham, commercial and, to a lesser extent, in CB transmitters.

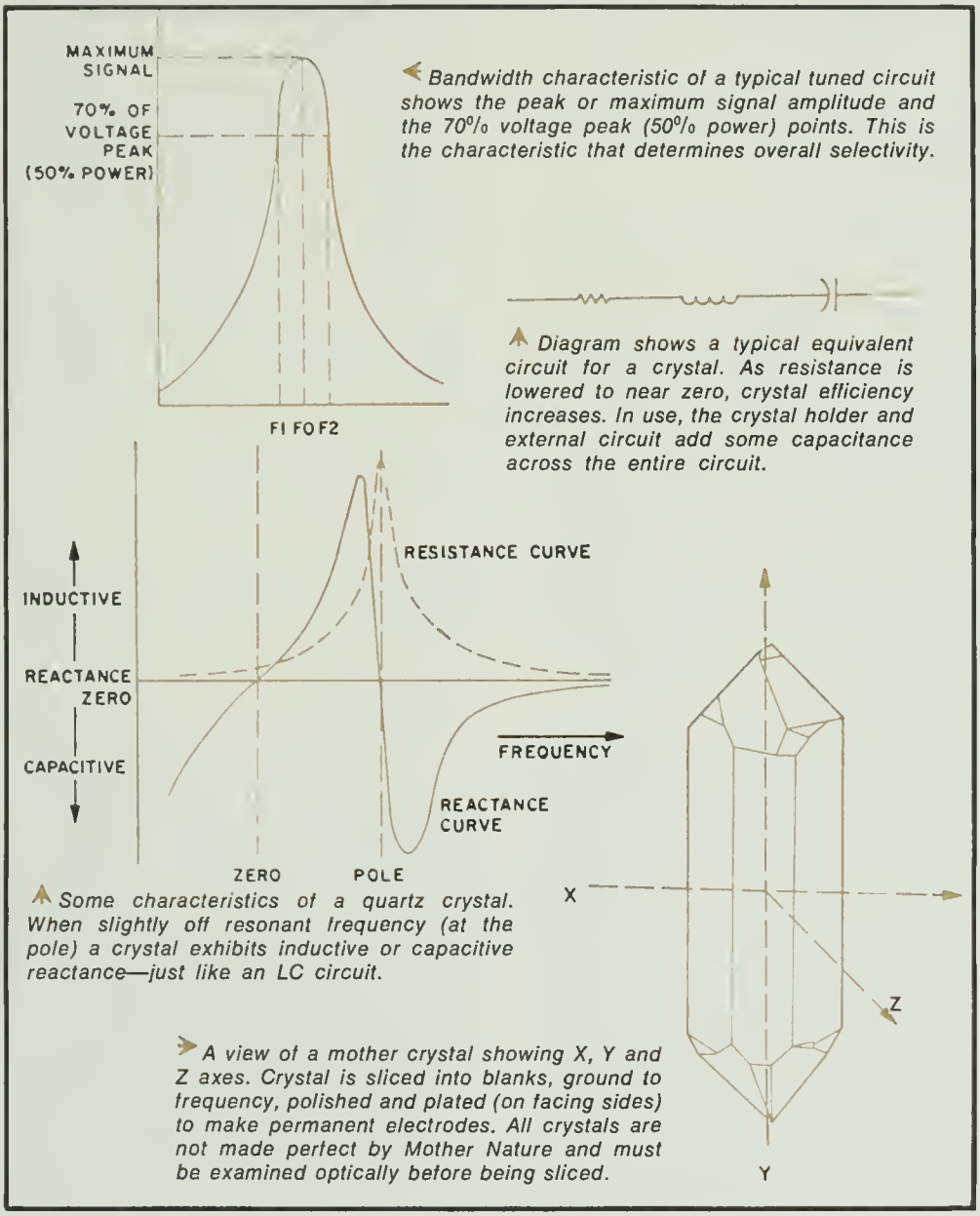
When a crystal is used to control the frequency of a radio signal or provide a source of accurate timing signals, either the pole or the zero may be used. Circuits making use of the pole allow more simple adjustment of exact frequency, while those making use of the zero often feature parts economy. Later we'll examine several of each type.

From rock to finished crystal. To perform its control functions properly, a quartz crystal requires extensive processing. The raw quartz crystal must be sliced into plates of proper dimension, then ground to the precise size required. Each plate must be as close to precisely parallel, and as perfectly flat, as possible. The electrodes must be in proper contact with the

polished plate; in many modern units, the electrodes are actually plated directly to the crystal surface, usually with gold.

The crystal plate is known as a blank when it is sliced from the raw crystal. The blank is cut at a precise angle with respect to the optical and electrical axes of the raw crystal. Each has its own characteristics for use in specific applications. Some, notably the X- and Y- cuts, are of only historic interest. The Y- cut, one of the first types used, jumped in frequency at critical temperatures. The X- cut did not jump, but still varied widely in frequency as temperature changed.

Today's crystals most frequently use the



Bandwidth characteristic of a typical tuned circuit shows the peak or maximum signal amplitude and the 70% voltage peak (50% power) points. This is the characteristic that determines overall selectivity.

Diagram shows a typical equivalent circuit for a crystal. As resistance is lowered to near zero, crystal efficiency increases. In use, the crystal holder and external circuit add some capacitance across the entire circuit.

Some characteristics of a quartz crystal. When slightly off resonant frequency (at the pole) a crystal exhibits inductive or capacitive reactance—just like an LC circuit.

A view of a mother crystal showing X, Y and Z axes. Crystal is sliced into blanks, ground to frequency, polished and plated (on facing sides) to make permanent electrodes. All crystals are not made perfect by Mother Nature and must be examined optically before being sliced.

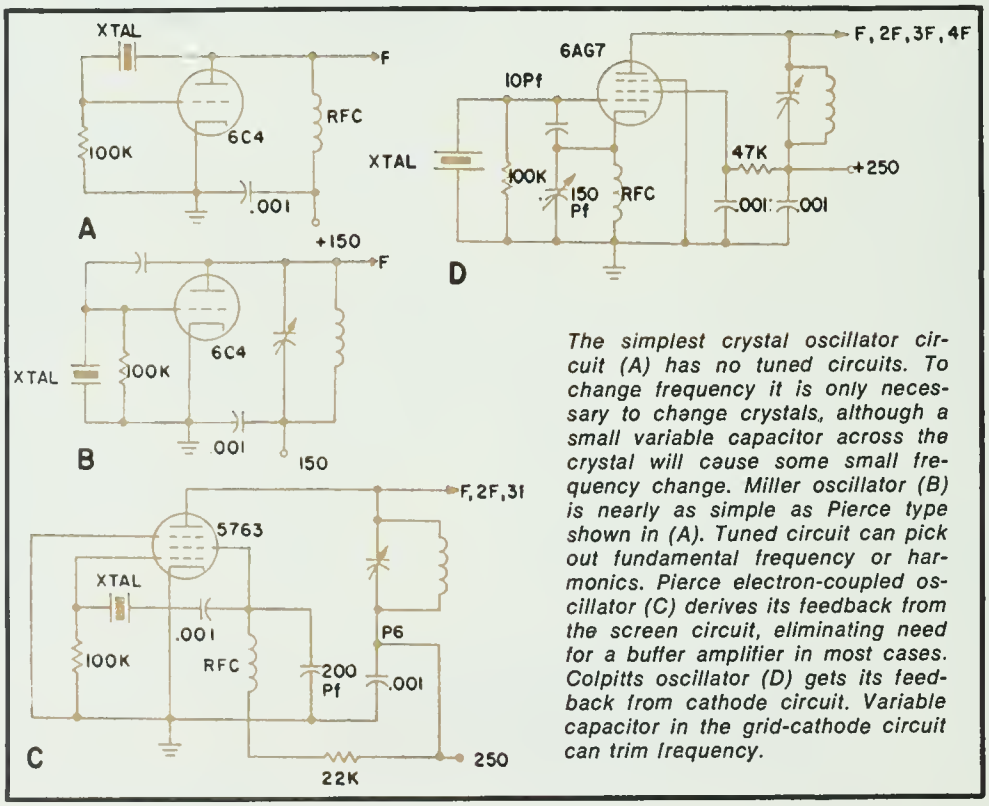
AT cut for frequencies between 500 kHz and about 6 MHz, and the BT cut for between 6 and 12 MHz. Above 12 MHz, most crystals are specially processed BT- or AT- cuts used in overtone modes. These cuts are important to crystal makers and not relevant to our layman's theory.

The blanks are cut only to approximate size. The plates are then polished to final size in optical "lapping" machines which preserve parallelism between critical surfaces. During the final stages of polishing, crystals are frequently tested against standard frequency sources to determine exact frequency of operation.

If electrodes are to be plated onto the crystal surfaces, frequency cannot be set precisely by grinding since the electrodes themselves load the crystal slightly and cause a slight decrease in operating frequencies. These crystals are ground just a trifle above their intended frequencies, and the thickness of the electrodes is varied by varying plating time to achieve precision.

Accuracy. The precision which can be attained in production of quartz crystals is astounding. Accuracy of ±0.001 percent is routine, and 10-time-better accuracy is not difficult. In absolute figures, this means an error of one cycle per megahertz. In another frame of reference, a clock with the same accuracy would require more than 11 days to gain or lose a single second.

However, such accuracy can be achieved only when certain precautions are taken. For instance, the frequency of a crystal depends upon the circuit in which it is used as well as upon its manufacture. For an accuracy of ±0.005 percent or greater, the crystal must be ground for a single specific oscillator. If ±0.001 percent (or better) circuit accuracy is required, it must



The simplest crystal oscillator circuit (A) has no tuned circuits. To change frequency it is only necessary to change crystals, although a small variable capacitor across the crystal will cause some small frequency change. Miller oscillator (B) is nearly as simple as Pierce type shown in (A). Tuned circuit can pick out fundamental frequency or harmonics. Pierce electron-coupled oscillator (C) derives its feedback from the screen circuit, eliminating need for a buffer amplifier in most cases. Colpitts oscillator (D) gets its feedback from cathode circuit. Variable capacitor in the grid-cathode circuit can trim frequency.

be tested in that circuit only. Thus, CB transmitters are on the narrow edge of being critical. This is why all operating manuals include a caution to use only crystals made specifically for that transmitter.

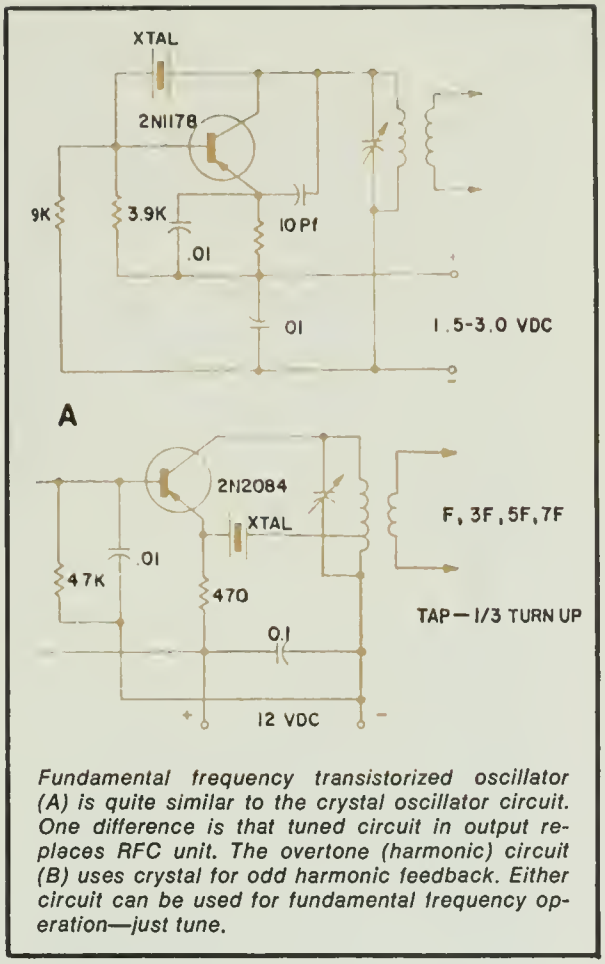
When one part-per-million accuracy is required, not only must the crystal be ground for a single specific oscillator, but most often the oscillator circuit must then be adjusted for best operation with the crystal; this round-robin adjustment must be kept up until required accuracy is achieved. Even then, crystal aging may make readjustment necessary for the first 12 to 18 months.

Frequency variation causes and cures. Possible variations in frequency stem from three major causes while cures depend entirely upon the application.

The most obvious cause of frequency variation is temperature. Like anything else, the crystal will change in size when heated and the frequency is determined by size. Certain cuts show less change with temperature than do others, but all have at least some change.

For most noncommercial applications, the heat-resistant cuts do well enough. For stringent broadcast station and critical time-signal requirments, the crystal may be enclosed in a small thermostatically-regulated oven. This assures that the steady temperature will cure one cause of frequency change.

The second well known cause for variation of frequency is external capacitance. Some capacitance is always present because the crystal electrodes form the plates of a capacitor where the crystal itself is the dielectric. Most crystals intended for amateur use are designed to accommodate an external capacitance of 32 pF, so if external capacitance is greater than this, the marked frequency may not be correct. Crystals for commercial applications are ground to capacitance specifications for the specific equipment in which they are to be used.



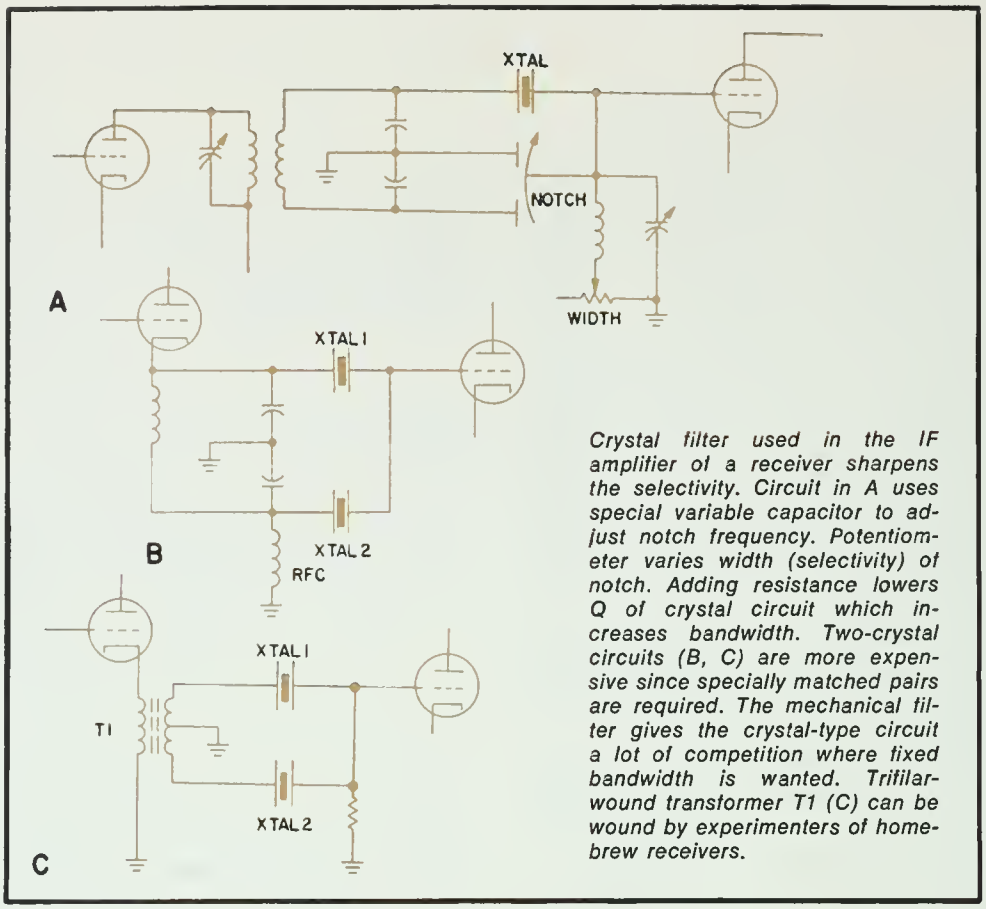
Fundamental frequency transistorized oscillator (A) is quite similar to the crystal oscillator circuit. One difference is that tuned circuit in output replaces RFC unit. The overtone (harmonic) circuit (B) uses crystal for odd harmonic feedback. Either circuit can be used for fundamental frequency operation—just tune.

CB crystals also are ground for specific equipment, although many transceivers employ the 32 pF standard set for ham applications.

When utmost precision is required, a small variable capacitor may be connected in parallel with the crystal and adjusted to change frequency slightly. The greater the capacitance, the lower the frequency. Changes of up to 10 kHz may be accomplished by this means, although oscillation may cease when excessive changes are attempted.

Like temperature caused variations, frequency variations due to capacitance may be useful in special cases. Hams operating in the VHF regions obtain frequency modulation by varying load capacitance applied to the crystal in their transmitters.

The third cause for variation of fre-



Crystal filter used in the IF amplifier of a receiver sharpens the selectivity. Circuit in A uses special variable capacitor to adjust notch frequency. Potentiometer varies width (selectivity) of notch. Adding resistance lowers Q of crystal circuit which increases bandwidth. Two-crystal circuits (B, C) are more expensive since specially matched pairs are required. The mechanical filter gives the crystal-type circuit a lot of competition where fixed bandwidth is wanted. Trifilar-wound transformer T1 (C) can be wound by experimenters of home-brew receivers.

quency is a change in operating conditions in the associated circuit. This cause is more important with vacuum-tube circuits than with semiconductor equipment. As a rule, operating voltages for any vacuum-tube oscillator providing critical signals should be regulated to prevent change.

Again, this cause can be used to provide FM by deliberately varying voltages.

A final cause of frequency variation, small enough to be negligible in all except the most hypersensitive applications, is crystal aging. When a crystal is first processed, microscopic bits of debris remain embedded in its structure. These bits are displaced during the first 12 months or so of use, but during that time the crystal frequency changes by a few parts per million. Extreme accuracy applications must take this change into account. For most uses, though, it may be ignored.

Using quartz crystals. After all the discussion of crystal theory, it is time to examine some typical circuits. While dozens of special crystal circuits have been developed for special applications, a sampling will suffice for discussion.

The simplest of these is the Pierce circuit. While at first glance this circuit appears to employ the crystal's zero to feed back energy from plate to grid, the pole is actually used through a mathematically-complex analysis. This circuit has one unique advantage; it contains no tuned elements and, therefore, can be used at any frequency for which a crystal is available. This makes it an excellent low-cost test signal source. The major disadvantage is that excessive current may be driven through the crystal if DC plate voltage rises above 90.

The Miller oscillator is almost as simple to construct and operate as is the Pierce and has an additional advantage of opera-

tion with overtone crystals. The capacitor shown between plate and grid is usually composed of grid-plate capacitance alone. The pole is used here also; energy feeds back through the grid-plate capacitance, and the pole selects only the parallel-resonant frequency (shorting the rest to ground).

The electron-coupled Pierce oscillator is similar to the basic Pierce. The tuned circuit in the plate offers the possibility of emphasizing a harmonic—an RF choke may be used instead if freedom from tuning is desired and fundamental-frequency operation will suffice.

One of the most popular oscillators of all time is the Colpitts Crystal oscillator sometimes known as the *grid-plate* oscillator. The feedback arrangement here consists of the two capacitors in the grid circuit; feedback is adjusted by means of the 150 pF variable capacitor (the greater the capacitance, the less the feedback) until reliable oscillation is obtained. Like the other three oscillators, this circuit employs the crystal pole frequency.

Since all four of these oscillator circuits utilize the pole for frequency control, exact frequency adjustment capability may be obtained by connecting a 3-30 pF trimmer capacitor in parallel with the crystal.

Crystal oscillators may, of course, be built with transistors, too. Feedback mechanisms differ somewhat because of the basic differences between tubes and transistors. In general, transistorized oscillators are more stable.

A crystal can also be used as the timing element of a clock. Crystal frequency is chosen at a low, easily-checked value such as 100 kHz. This frequency is then divided and redivided by synchronized multivibrators to produce one-cycle-per-second pulses. These may then be counted by computer counting circuits.

In addition to being used as oscillators and timing elements, crystals find wide application in filters. While all circuits shown use vacuum-tubes, transistors may be substituted without modification of the filter circuits themselves if the impedances are right.

The single-crystal filter circuit provides spectacularly narrow reception. When the notch control is set to precisely balance out the crystal stray capacitance, the resonance curve of the filter is almost perfectly symmetrical. When the notch control is offset to one side or the other, a notch of almost infinite rejection appears in the curve (the pole). The width control varies effective Q of the filter.

More popular for general usage today is the bandpass filter. These filters pass a band of frequencies without excessive loss and reject all frequencies outside this band. Both circuits make use of matched crystals (XI and X2)—the pole of one must match the zero of the other for proper results. When this condition is met, the reactances of the two crystals cancel over the passband. The passband is roughly equal to the pole-zero spacing.

While the two circuits shown are virtually identical in operation, the transformer-coupled circuit is easiest for home construction. The only critical component is the transformer. It should be tightly coupled, with both halves of the secondary absolutely balanced. This is done by winding a trifilar layer of wire (wind three wires at the same time); the center wire becomes the primary winding and the remaining two wires become the secondary. The left end of one secondary half connects to the right end of the other, and this junction forms the center tap. The remaining two ends connect to the crystals. If you have sufficient patience to wind on it, a toroid form is recommended. The only absolutely critical requirement of the transformer, however, is that it have no resonant frequencies anywhere near the operating region. T.M.

See also: CITIZEN'S BAND RADIO.

Getting the Static Out of Your Boat Radio

Buying an expensive suppression kit is one answer, but for much less you can cut a great deal of static yourself

MOST OF THE MARINE radiotelephones used on outboards are amplitude modulated, operating on the mobile marine band between 2 and 3 megacycles. Oddly enough, this is the frequency band that is most susceptible to interference generated by the outboard engine. Not only can this interference ruin voice communication, it can also interfere with direction finders, depth finders, and "fish finders."

Outboard engine manufacturers are becoming aware of the multitude of outboard powered craft equipped with radio and electronic navigational equipment and are now making suppression kits. Here are details on some of these kits which should greatly reduce radio interference, discrepancies with radio direction finders, and "spikes" on the dials of depth finders.

The illustrations are a brief outline of the suppression measures designed to quiet various types of outboard ignition systems. For complete details and prices, consult your outboard dealer.

Manufacturers kits will not affect engine performance provided the ignition system is in tip-top condition. Outboards that have a tendency to foul spark plugs may have greater difficulty when the suppression kit is installed.

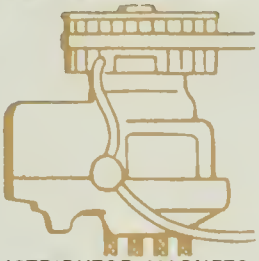
Before adding suppression, correct the causes of fouling. Look for excessive combustion chamber deposits, incorrect breaker point synchronization, clogged passages in the intake manifold bleed-off system, tracks in the distributor cap, improper carburetor adjustment, lack of synchronization of spark advance and carburetor butterfly.

Some outboards, operated at low speed (such as while trolling), may misfire from a carbon build-up between the plug electrodes, even though the spark plug insulator nose remains fairly clean. Outboards not usually prone to this type of fouling may become susceptible to "gap bridging" when suppression kits are installed. There is evidence that outboard coil-battery ignition is less troublesome in this respect. The coil, etc. must be properly shielded and filtered. Whatever the ignition system of your out-

35-40 HP

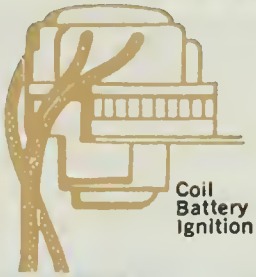
FLYWHEEL MAGNETO

50-60-75 HP

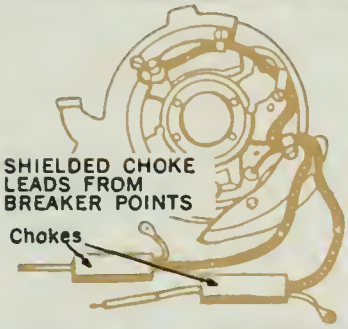


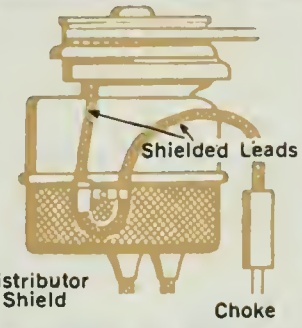
DISTRIBUTOR MAGNETO

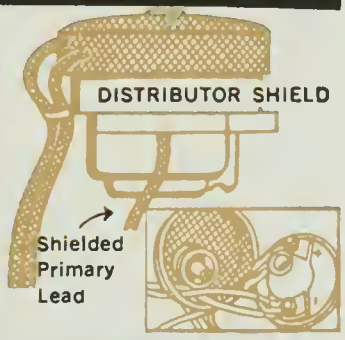
75 HP with Alternator



MODIFICATIONS TO PRIMARY AND SECONDARY



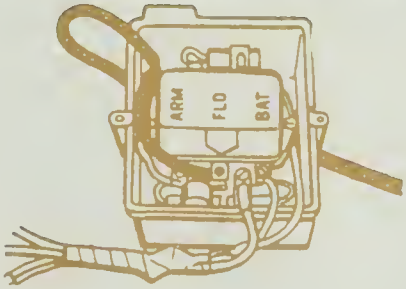




SPARK PLUG CABLES

SPARK PLUG TYPES

GENERATOR CHARGING SYSTEM

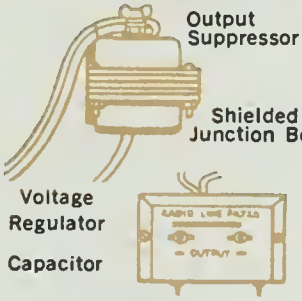


SHIELDED LEADS

SUPPRESSOR

CAPACITORS

ALTERNATOR



▲*Suppression kits available for Outboard Marine Corporation's Johnson and Evinrude engines*

board, it is recommended that spark plugs be inspected frequently.

Resistor-type spark plugs are included in the suppression kits for flywheel magnetos. However, with a shielded system, the outboard boatman has a choice of regular or resistor plugs. The regular plugs will generally give better performance in prolonged trolling operations.

Unless you have a thorough knowledge of outboard ignition and charging systems, some outboard manufacturers recommend that these kits be installed by their dealers.

Whether or not you should go to the expense of having a suppression kit installed depends upon the severity of the interference your outboard produces, and the amount of time you use your radiotelephone with the engine running. If you feel the expense unwarranted and you have some knowledge of outboard ignition systems, electricity and electronics, you may want to do some suppressing yourself. If so, here are some tips you may find useful.

Use an approved marine-type antenna (not an automobile antenna) matched to the electrical characteristics of your particular radiotelephone and the frequency band on which it operates. Consult your dealer on this.

Install the antenna on the side of the boat opposite the remote control engine panel and as far forward in the bow as possible.

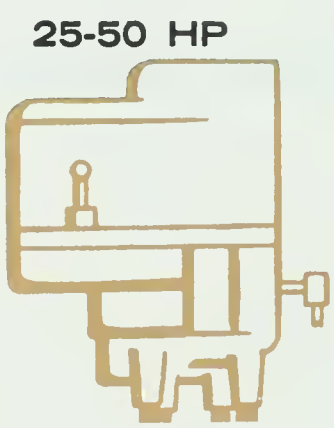
Use a coaxial shielded lead-in (such as RG8U). Be sure to ground the metal braid shield to the cabinet of the radiotelephone.

Unless your boat has a metal hull, you will need a ground plate of at least 12 square feet of copper sheet (an FCC requirement) or the commercially available compact ground plates such as the Dynaplate, RGP, or equivalent. Grounding the radiotelephone to your outboard engine is not recommended.

The ground plate should be located as close to the radio transmitter as possible and connected to the radio ground terminal through a #10 ground wire.

There should be a common point where every metallic object on the boat is grounded. This includes the engine frame, the ground-side of the battery, the cases of all electrical and electronic equipment, bilge pumps, through-hull fittings, and all other metallic objects. The radio ground plate should not be the common ground point, but should be connected to it by a #10 wire. Such a common ground point will:

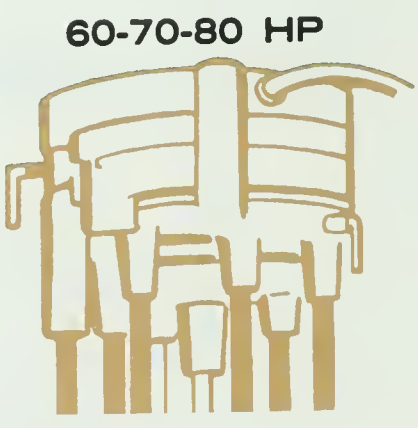
1. Minimize radio interference.
2. Provide a low-resistance electrical



DISTRIBUTOR MAGNETO

Mercury outboard motors use a magneto for ignition with their lower power engines.

Higher horsepower engines rely on battery ignition rather than magneto. Newest models, with extra power spark, require little shielding.



COIL BATTERY IGNITION

path between otherwise isolated metallic objects, particularly those in contact with salt water, thus reducing the possibility of galvanic corrosion or electrolysis.

3. Prevent the possible existence of high voltages on exposed metallic objects, such as might be the case when shore power is used.
4. Provide a low resistance path to ground in case of being struck by lightning.

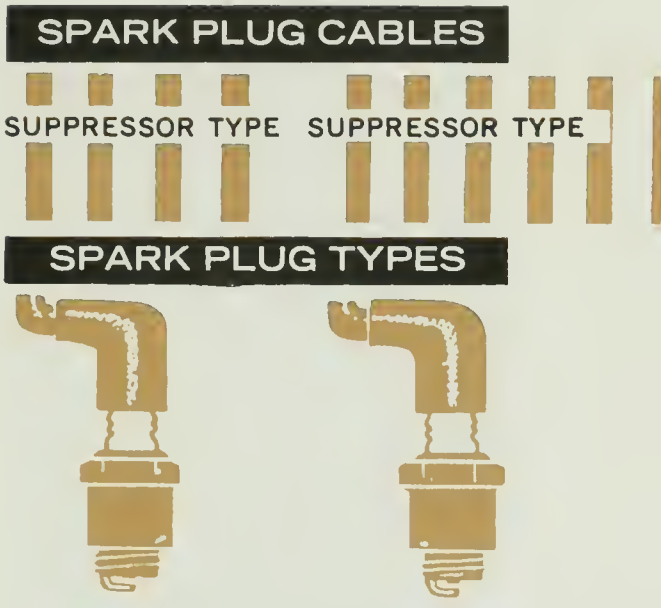
Check all wiring to make sure no wires run through a leaky bilge.

Take power directly from the battery for your radiotelephone. Don't tap into the accessory-ignition switch where feedback and intercoupling can result, causing interference between the boat's electrical system and the radio circuit.

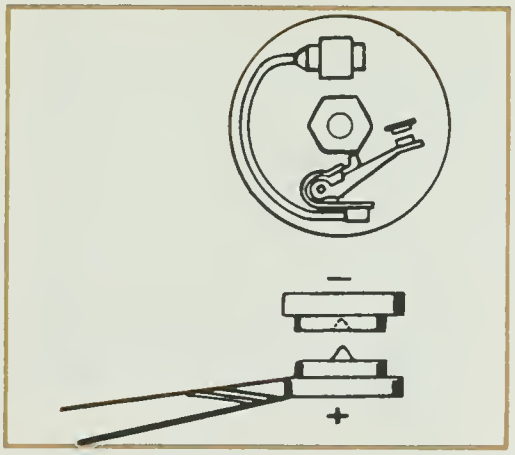
The ignition primary is a chief offender. Although breaker points produce a low-frequency signal, such interference is usually confined to the broadcast band and does not affect the radiotelephone. However, "point bounce" not only affects the engine performance adversely, but can blast high-voltage, high-frequency interference in the 2-3 megacycle band all over the boat's wiring system.

Point bounce is the intermittent fluttering of breaker point contacts at high rpm. They actually bounce, just as a steel hammer bounces when it is struck against an anvil. Point bounce is caused by insufficient spring tension, allowing the points to bounce at high rpm or to make poor contact, both of which cause arcing and consequent radio interference, as well as misfiring. Too much spring tension causes excessive rubbing block wear. Be sure the spring tension is adjusted to the engine manufacturer's specifications.

Two-way radio communication can often be improved and breaker point life extended by mating the distributor condenser capacity to the type of operation. Taking the allowable MFD range for your particular engine, select the high end of the MFD range for start-stop, long idle operation.



Mercury's complete suppression harness for horsepowers shown consists of a distributor cap, distributor-coil cables, and spark plug suppression cables. Make no attempt at "do-it-yourself" installations when using automotive type suppression cables.



Point performance can often be improved by mating condenser capacity to type of operation. Use highest MFD limit for long idle, lowest for high-speed or heavy-duty.

Select the lower end of the MFD range for sustained or high speed operation.

For example, if the condenser capacity for your engine is from 0.18 MFD to 0.25 MFD, use a 0.18 MFD condenser for high speed or sustained operation. Use a 0.25 MFD condenser for start-stop, long idle operation.

Condenser capacity too high will show up as a crater in the positive contact. Condenser capacity too low shows up as a crater in the negative contact. Make sure there are no loose connections in the primary wiring or abnormal generator charging rate before you change the value of the distributor condenser.

On outboard engines using coil-battery ignition, here are two tips that will greatly reduce the amount of ignition interference transferred to the entire system:

1. Install a coaxial 0.1 MFD capacitor (Sprague 48P9 or JN-17-907 or equivalent) as close to the coil terminal as possible. The capacitor should be installed at the primary terminal that is connected to the ignition switch. Remove this wire, run a short wire from the coaxial capacitor terminal to the coil terminal, then reconnect the coil wire to the other terminal of the coaxial capacitor.
2. Remove the ignition coil and its mounting bracket. Clean the paint off the coil mounting bracket and the engine block, then reassemble tightly. Coil and components must also be shielded.

Magneto grounding wires, or battery ignition wires, running from the engine to the control panel ignition switch are sources of annoying radio interference. These should be shielded and the metallic braid grounded. Do not attempt to alter remote control cables. However, large diameter woven metal braid can be slipped over the electrical cable assembly and should be grounded, both at the engine and control panel.

If your outboard is equipped with a tacherator charging system, you may be experiencing radio interference from it and blaming it on the ignition system. Rough, uneven commutator bars and worn brushes create many small arcs as the armature revolves, generating radio frequency interference heard as a high-pitched whine in the receiver as the engine is revved up.

Be sure the commutator bars are clean and, if necessary, turned down in a lathe to true up. If brushes are worn to half their original length, they should be replaced. Then remove the old "bypass" capacitor and install a coaxial 0.5 MFD capacitor with a current rating that exceeds the current rating of the generator (Sprague 48 P 18, JAN 17-965, or equivalent). Use the old capacitor mounting bracket to ground the new coaxial capacitor and run a short #10 gauge wire from the ARM post of the generator to the capacitor terminal. Connect the original ARM wire to the other terminal of the coaxial capacitor.

Keep the generator cover free of paint and grease—a good ground through the generator base is extremely important!

If your outboard engine is equipped with lator. Although the voltage regulator con a generator it will also have a voltage regu ducts current at low voltage, the multiple contacts vibrating can make hash of radio reception. The interference is heard in the receiver as an intermittent and erratic popping noise that is not affected by engine rpm.

To eliminate this hash, use two coaxial 0.5 MFD capacitors with a current rating exceeding the current rating of the generator, connected in series with the voltage regulator. One capacitor is connected between the battery lead and the BAT terminal of the voltage regulator, the other between the generator ARM terminal and the ARM terminal of the voltage regulator.

Metal braid shielding over the wires between the generator and the voltage regulator will help to eliminate radiation of interference. Be sure to ground both ends of the metal braid shield.

If your outboard is equipped with a tachometer you may be experiencing annoying interference from it. The tachometer receives electrical impulses from the ignition primary and with these impulses a hash of electrical interference that is radiated from the wiring, transferred to other wiring, and hence all over the boat. Such interference can be substantially reduced, if not entirely eliminated, by shielding the entire length of tachometer wiring from engine to instrument panel. Be sure to ground the metal braid to engine.

Some tachometers may require adjustment, or may not work at all if shielded, because the shielding may change the characteristics of the impulses.

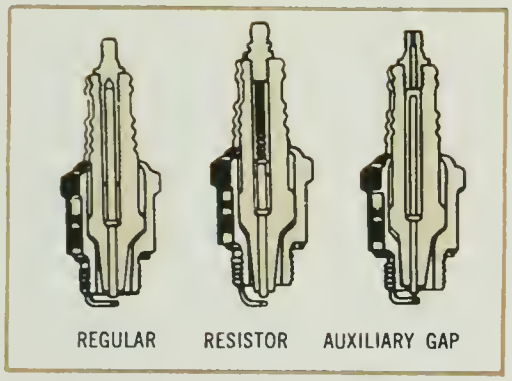
There is a popular misconception that spark plugs are the only source of radio interference encountered on outboard engines. This is a hold-over from the days when the early outboard engine had nothing electrical about it except a flywheel magneto and the spark plugs. But this is no longer true when today many outboards boast as much or more electrical equipment as any inboard. For this reason, any mention of spark plug interference has been left until the last so that other sources of radio interference would be made known to you first.

Because of the high voltage employed in the ignition secondary circuit, the spark across the gap generates very strong radio interference, heard in the radio receiver as a rapid popping noise that increases in pitch to a loud buzz as the engine is revved up. In most cases, the installation of resistor spark plugs will quiet the radio interference generated by the spark plugs.

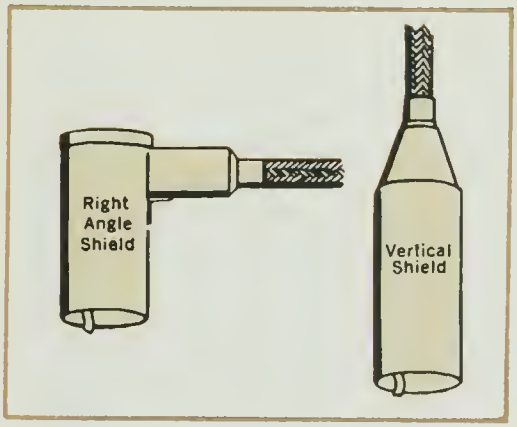
Outboard engines are more prone to spark plug fouling than inboards are, and many outboards are used in slow-speed operation such as trolling, making spark plug fouling more of a problem.

If your outboard engine is prone to fouling spark plugs, the resistor spark plug may increase this tendency. In such cases, use shielded spark plug cables and spark plug shield cans and use the regular plug rather than the resistor plug. Shielded systems are not recommended for outboards with flywheel magneto ignition systems since they must also be shielded.

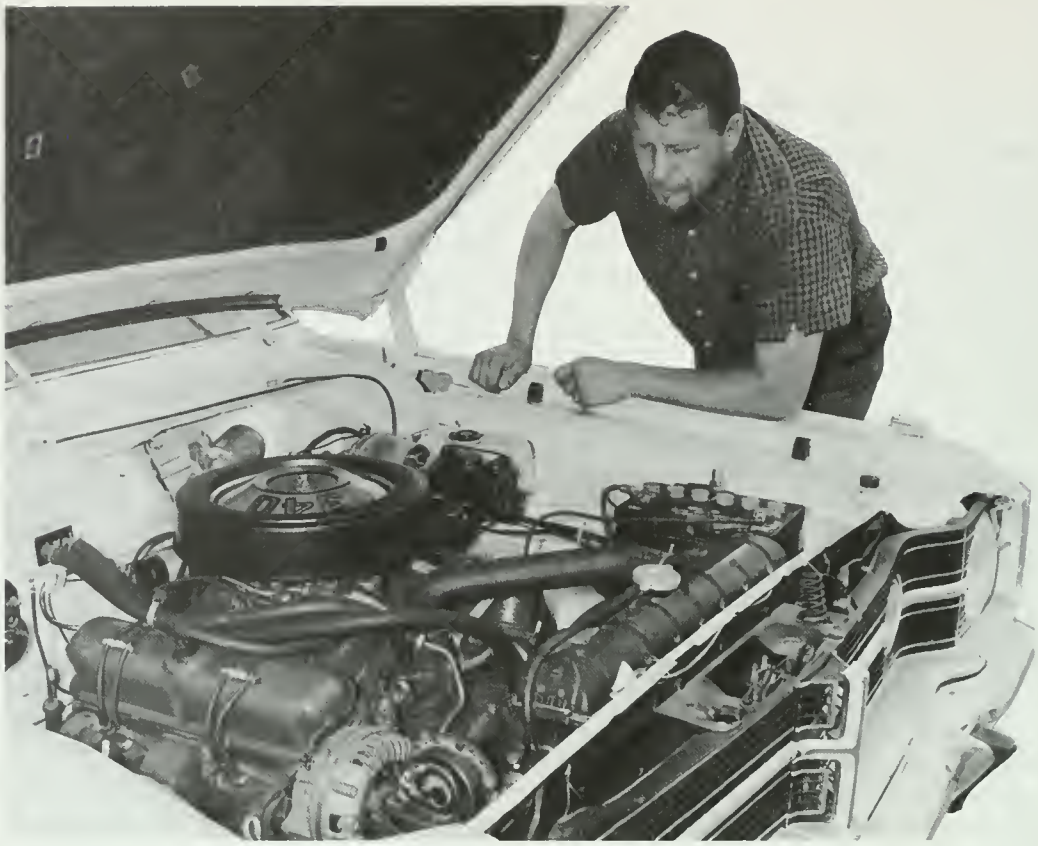
See also: BOAT ENGINE; CITIZEN'S BAND RADIO.



▲ *Regular spark plug is adequate in most cases; resistor is required only in extreme cases of interference. Use auxiliary gap in extreme cases of plug fouling.*



➤ *With shielded spark plug cable and plug shield cans, you can use a regular spark plug, which will provide better performance in prolonged slow-speed operation.*



Electronic Equipment for Weekend Mechanics

An investment in a few electronic analyzers can help you avoid costly repairs by a professional garageman

WHY SPEND MONEY on automotive diagnostic equipment if you do not know enough about car engines to make your own repairs? One reason is a professional repairman will not be able to talk you into paying for unneeded repairs if you can tell him what is wrong with the engine. Moreover, you will soon discover that many service jobs related to engine tune-up or other electrical system functions are easy to do yourself. For example, there's no trick to replacing a spark plug; but you have to know which spark plug needs cleaning or replacement.

Every piece of equipment described here can be connected to the car engine in seconds, without removal of engine parts that might be difficult to replace. Also, each test instrument comes with clear, step-by-step instructions. You will be able to perform engine tests correctly on the first try, and you will understand what the test results mean. If you are unfamiliar with automotive testing equipment, your main problem is deciding what type of equipment would be most useful to you. It is easy to go overboard and buy too much test gear; or you can err by wasting money on equipment that will not serve

all your needs. This roundup of automotive tune-up analyzers will clue you in on the types of instruments that have the broadest general appeal and usefulness. But you should do some extra looking around in shops where the analyzers are sold, and study catalog specs to make sure that you are getting the most per dollar invested.

Three musts for engine tune-up testing are: a tachometer to measure engine rpm; dwell meter to measure the performance of the cam that operates the distributor breaker points; and a timing light to determine whether the number one spark plug is sparking at the correct time in relation to piston position on the compression stroke. To test the car's electrical system more completely, you should also have a DC voltmeter, DC ammeter reading up to 90 amperes, and an ohmmeter for resistance checks. If you already own some or all of this more common variety of electronic test equipment, just look for a timing light, and for tach and dwell meters—either as separate or combined instruments. If you lack all or most of the desired equipment, you can save money by investing in an engine analyzer that combines all of these test functions in one portable unit.

If you are already confused by some of the automative terminology, get a couple of library books and read up on automotive ignition systems. Also check your electronics supply store for informative paperbacks.

Timing lights. Each engine spark plug must fire at precisely the right time, in relation to its piston position; if spark timing is off, the engine may overheat, suffer loss of power, exhibit poor acceleration, waste fuel, and perform poorly in other respects. To check the all-important spark timing you need a stroboscopic light.

One cable of the timing light is connected to an AC or DC (car battery) power source, depending on the type of light; the other cable is connected to the number one spark plug. Very low cost neon timing lights require only one connection—to the spark plug. Each time the spark plug fires, the timing light flashes. This flashing light is aimed at a stationary, calibrated marker and at a moving indicator mark located on the engine's crankshaft pulley, or flywheel. As the indicator mark spins around, the stroboscopic light makes it appear to stand still at a specific point next to the marker scale. If the timing is off, the indicator mark will appear to be in the wrong position. This initial timing test is usually performed with the distributor vacuum hose disconnected. If the timing needs correcting, all you need do is loosen a hold-down bolt on the distributor and twist the distributor body slightly until the indicator mark moves to the proper scale position. It is that easy.

The same timing light can be used to make a rough check of the centrifugal and vacuum advances of spark timing. More accurate testing and adjustment of these advances requires the use of a special ignition advance tester—a timing light having a built-in meter. You might want an advance tester some day, but chances are you can get along nicely with the basic timing light.

You can buy a neon timing light for under $5, but the red light is so weak that you will probably have to use it in a darkened garage or under a blanket thrown over the car hood. These lights are completely accurate; you merely save money by sacrificing convenience. You can find these neon lights in department and discount stores having automotive sections, and in auto supply stores.

Powered timing lights that use high-voltage (300-600 VDC) xenon flash tubes can be used in broad daylight without eye strain. These lights are also connected to the number one spark plug which acts as a trigger mechanism for the synchronized flashing. Some lights work off a 110-volt

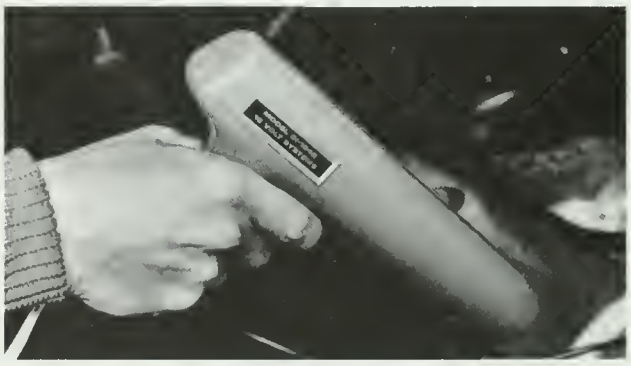
AC power line, others draw power from the car battery. The AC types are usually priced lower than the DC models which can be used anywhere. You can save money by purchasing lights in kit form.

To further illustrate the variety of timing lights available on the market, we might mention a Penske DC power timing light sold by Sears for about $27. Incidentally, Sears also offers a neon light, a DC-boosted neon light, and an AC "white" light for much less.

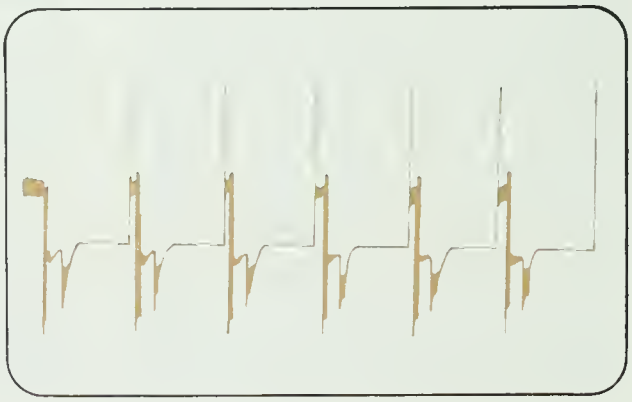
One new 12-volt deluxe timing light utilizes an additional convenience feature —a new-style, low-voltage inductive trigger pickup that clips onto the spark plug cable even when the engine is running. You do not have to fuss with spark plug adapters of the kind that must be used with other types of timing lights. A coil inside the clamp picks up triggering pulses from the spark plug cable without actual physical contact with the ignition circuit.

Following assembly instructions, a 13-year old can put the timing light together in a few hours; an experienced kit-builder can do the job in a couple of hours. You should not run into problems assembling the simple solid-state inverter circuit and xenon flash tube, and the inductive pickup. To balance the triggering circuit, you adjust a 200-ohm control in the circuit using a built-in neon indicator or a voltmeter as voltage indicator to obtain the required 600 VDC. If the timing light fails to function properly after these adjustments, do not assume that some component is defective. Just connect the light to the car engine as for a normal timing test (but with the unit's case open), start the engine, and again adjust the 200-ohm control. Chances are you will have the timing light flashing normally within seconds.

Engine analyzers. Engine tune-up equipment, including dwell meters and tachometers, come in a bewildering variety of types ranging from simple, hand-held models serving limited test functions to more costly multi-functional units. If you already own conventional electronic test equipment (voltmeter, ohmmeter and DC ammeter), perhaps all you need to buy is a relatively inexpensive combination dwell meter and tachometer. Because there are



This inductive pickup light is powered by the car battery. Pickup can be attached to spark plug lead even with engine running.



Normal "parade" pattern of auto ignition for a 6-cylinder engine. Each re-occurring pattern should be identical for engine operating normally.

just too many choices to permit detailed listing here, consult the catalogs of such mail-order houses as Sears, Lafayette and Radio Shack, and investigate local auto supply outlets.

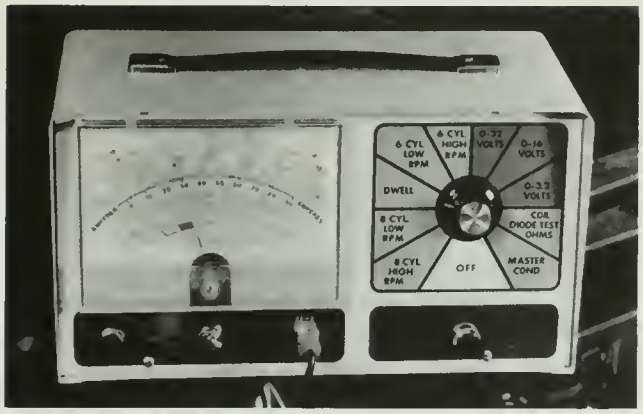
Assuming that many readers might be more interested in the multi-functional analyzers, a Radio Shack kit and a Lafayette factory-wired model were selected for comparative examination. These units are modestly priced when compared with Penske analyzers.

Heathkit's CM-1050 Engine Analyzer (about $65) is worthy of serious consideration. This "professional-grade" instrument tests conventional, magneto, transistor, and most capacitive discharge ignition systems regardless of voltage or type of grounding. Its functional components include a tachometer, dwell meter, voltmeter, ohmmeter, ammeter, substitution condenser, and provision for testing spark output. Except for ohmmeter adjust, no in-use recalibration of the instrument is required. Accuracy is claimed to be ± 3% on all measurement ranges, and metal-film resistors are used at critical circuit locations to ensure stability over wide temperature range. The analyzer operates off three C cells.

Radio Shack's ArcherKit Universal Auto Analyzer kit (about $55) went together easily in about six hours, and performed on the first try. In addition to clear assembly and operational instructions, you get a 56-page engine specifications manual detailing useful tune-up information for both domestic and foreign cars, and trucks made in the 1960 to 1970 period.

The 7-inch, 10-scale meter is easy to read. All scales (except the ohms scale) read from left to right, and each scale is color-coded to the proper position of the function selector switch. The completely portable instrument is powered by four C cells located in a rear compartment cables and reference literature.

This kit lets you assemble your own engine analyzer.



Solid-state engine analyzer includes a tach, dwell meter, VOM and master condenser for substitution testing.

There are two rpm scales (0-1200 and 0-6000 rpm ranges) and four selector switch positions for choosing the right range and to adjust the circuitry for 4, 6 or 8 cylinder engines. This tachometer requires preliminary calibration which is accomplished with a special cable that provides a 60Hz signal from the house power line; this is a one-time calibration. However, to ensure accurate rpm readings, you must use the RPM CAL and RPM SET controls to adjust the meter pointer to full-scale

indication before each rpm measurement. It's a simple procedure requiring only seconds to accomplish.

Two cam dwell scales provide 0-45, 0-60 and 0-90 degree measurements for 8, 6 and 4 cylinder engines respectively. The separate 0-3.2 VDC and 0-16 VDC scales are used to test battery voltage or battery capacity (make voltage readings while cranking the engine); also for checking voltage drop in cables, to check solenoid operation, and to pinpoint broken or loose connections in the low-voltage point and distributor wiring.

The ammeter, which has a 0-90 ampere range, is used to check the car regulator, generator or alternator system; a special connecting cable, with shunt bar, is provided for this purpose.

The ohmmeter (0-20,000 ohm range) is used to check the ignition coil, the resistance of spark plug resistance wire, open circuits in fuses and bulbs, and electrical continuity in any wiring circuit.

A "Hi-Lo" diode/leakage scale provides a quick test for condenser leakage. Another sure way to test a suspected condenser is to use the substitute condenser contained in the analyzer. Diodes used in alternators are also tested using the diode/leakage scale. And, finally, there's a spark output indicator light on the front panel; this and the Hi-Lo spark scale are used to compare the relative potencies of sparks in different engine cylinders.

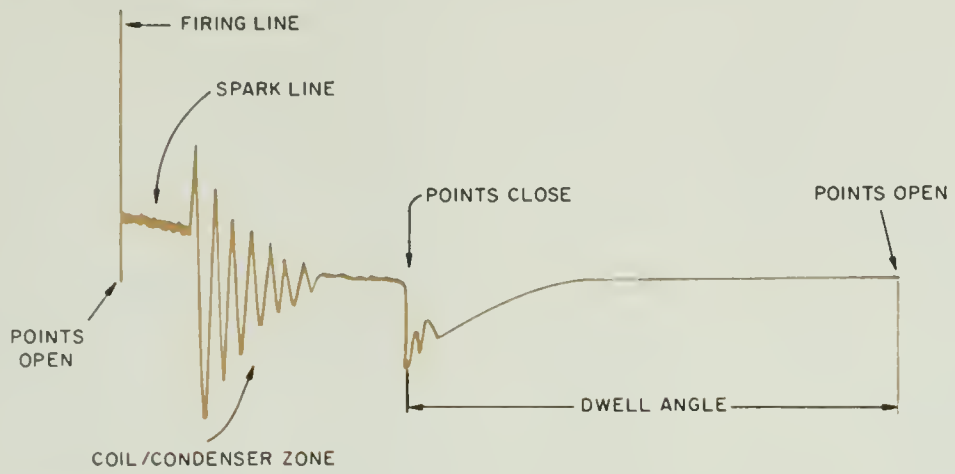
Lafayette analyzer. The Deluxe Solid-State Engine Analyzer, about $50, sold by Lafayette is a factory-assembled unit that is quite similiar to the Radio Shack analyzer just described. It features a 6-inch d'Arsonval meter with nine easy-to-read scales which are very prominently color-coded with the function selector switch. Every attempt has been made to keep the number of controls at a minimum. Aside from the function selector, you find only an ohms-adjust knob and a toggle switch that selects either the general test input or the amperes input jack.

The two voltage scales handle three ranges —0-3.2, 0-16 and 0-32 volts. The DC ammeter has a —5 to +90 range, and the ohmmeter has a 0-100,000 ohms range. These three functions have broader ranges than those found on the Radio Shack analyzer. However, the dwell and rpm ranges are comparable, and there's a substitute test condenser, a capacitor and coil testing scale, but no spark output indicator. Diodes are tested by measuring the resistance in two directions, as with the Radio Shack analyzer, but a separate diode Hi-Lo scale is not provided. There is no need to preset the meter pointer before each rpm measurement.

The Lafayette analyzer is powered by a single size D cell located in a rear compartment which is also used to store cables and reference material.

The instrument can be used to test all 4, 6 and 8 cylinder engines. Test readings on an 8-cylinder engine, using the Lafayette and Radio Shack analyzers, yielded virtually identical results. Both units are equally simple to connect to the engine. For example, to measure dwell angle or rpm, just fasten one alligator clip to ground and the other to the primary terminal of the coil, set the function selector switch to the proper position, and start the car engine. A minor shortcoming of the Lafayette analyzer is the modest engine specifications booklet provided with the instrument. But this information is easy to acquire for any car; in fact, most of the specs you need are on a label somewhere near your radiator or engine.

Heathkit ignition scope. Most weekend mechanics can get along very nicely with the types of tune-up instruments already described. But if you ever see an ignition oscilloscope in operation, you are going to want one. The only problem is that a factory-wired, professional scope costs upward



Shown here is a normal secondary ignition pattern, for a standard ignition system, as seen on the CRT screen of an ignition scope. Aberrations in the indicated zones reveal the malfunctions listed below. The pattern produced by a capacitive-discharge ignition system is different, but it too can be used to diagnose ignition problems.

Firing Line: Shows voltage needed to break down plug and rotor gaps; these lines should be about the same for all cylinders.

Spark Line: Indicates the voltage needed to sustain the spark. Depending on whether this line is too long and low, too short and high, slanted, broken or absent, the following problems can be spotted: shorted or fouled plug; too close or too wide plug gaps; defective resistance wire to spark plug; excessive gap between end of rotor and spark plug wire contact in distributor cap; open plug or wire; defective distributor; resistive plug or wire; defective distributor rotor.

Coil-Condenser Zone: Reveals dissipation of energy after the spark plug fires. If these oscillations are low or absent, look for a defective condenser or coil.

Points Close Signal: Breaker points close. If the first oscillation is not the largest, points are not closing properly. Excessive cam wobble is indicated if the degree of variation in this area is greater than specified by the manufacturer.

Dwell Angle: Length of this section indicates the time during which the breaker points are closed. Use the CRT screen scales to measure the dwell angle. Random flashes along the dwell line indicate a loose connection in the primary circuit, anywhere between breaker points and distributor and battery.

Points Open Location: Breaker points open. Look for a sharp 90-degree rise indicating desired production of high voltage (the "Firing Line" for the next cylinder). Intermittent flashing at this location indicates that points are arcing.

Jittery Pattern: If the entire waveform has the jitters, look for a loose or corroded high-tension lead.

from $250, a bit too much for most amateur mechanics. But if you can afford a relatively modest outlay of about $130, you can have an excellent scope by assembling Heathkit's CO-1015 Solid State Ignition Analyzer. Thanks to the excellent assembly instructions, and provision of a special wiring harness, the kit goes together easily. And when you get through, you have a really spiffy-looking instrument that's almost too nice to take into a greasy garage. The scope is powered by 110-volt AC current, but for about $25 more you can have an optional power pack (COA-1015-1) that permits operation of the scope off the car battery for road tests; just plug into your car cigar lighter, and you're in business. If you build this scope, you won't throw your other test equipment out of the window; but the scope is the first instru-

ment you will reach for when an ignition check is in order.

This solid-state scope, in a housing measuring about 7 x 10 x 17 inches, features a circuit with 24 transistors, 9 diodes and a 5-inch diameter CRT display tube contained in an anti-magnetic shield. A connecting cable, 12 feet long, terminates in four different clamps that can be attached quickly to the car engine. Alligator clips are used for ground and coil primary connections, a T-clamp is for the coil's high-tension lead, and an inductive pickup, very much like the one used with the Heathkit timing light, clamps onto the number one spark plug wire. The scope can be used on 3, 4, 6 or 8 cylinder engines having standard transistor, or capacitive-discharge ignition systems.

Most of the information is displayed as a waveform on the CRT screen, but there's also a small tachometer having 0-1000 and 0-5000 rpm ranges. You will want to use the larger scale on your more conventional tachometer for accurate rpm measurements, but the scope tach is handy for checking rpm while making other observations or measurements with the scope.

You can select waveforms representing either the primary or secondary circuits of the ignition system. The primary pattern is mainly useful for locating poor electrical connections between the vehicle battery and grounded side of the breaker points. The secondary pattern is the real workhorse because it provides a wealth of information about what is going on in the engine. You can view the waveform three different ways. In the so-called "parade" pattern, the waveforms for all cylinders are shown simultaneously in their normal firing sequence; thus you can instantly compare all cylinders and spot such malfunctions as a misfiring spark plug—and know which spark plug is at fault. Another way to detect malfunction that is not immediately evident through observation of the parade pattern is to superimpose all cylinder waveforms to create one composite pattern; if one or more cylinders are out of step, you know it immediately. The third method of analysis is to go back to the parade pattern, then use the horizontal expand and position controls to enlarge the pattern of any one cylinder for closer inspection. It is this capability that makes the instrument such a unique diagnostic device. You can easily measure the cam dwell angle using scales on the CRT screen, and by comparing various portions of the overall waveform with reference drawings provided in a comprehensive manual that comes with the instrument you can spot all sorts of ignition troubles.

The chart that accompanies the drawing of a normal waveform for a standard ignition system reveals the remarkable versatility of an engine analyzer scope. The waveform produced by a capacitive discharge ignition system has a different shape, but it can be used in similar fashion to spot malfunction in the ignition circuitry. After testing the Heathkit scope we could think of only one significant improvement that you can easily add. If you use the scope in an unusually bright area, you will be able to see the scope pattern more easily if you construct a viewing tube — from wood, metal or cardboard—that you can place between the scope screen and your eyes. This is a minor problem because the trace is bright enough to be easily visible under most observation conditions. And one more advisory comment. If you buy the optional power pack and use the scope for road tests, be sure to place the instrument where the driver cannot possibly see the screen; the CRT display is so fascinating to observe that the most well-intentioned driver won't be able to resist frequent glances. And that could lead to an accident and more serious and costly repairs than just touching up the ignition system. J.H.

See also: ELECTRICAL, AUTO.

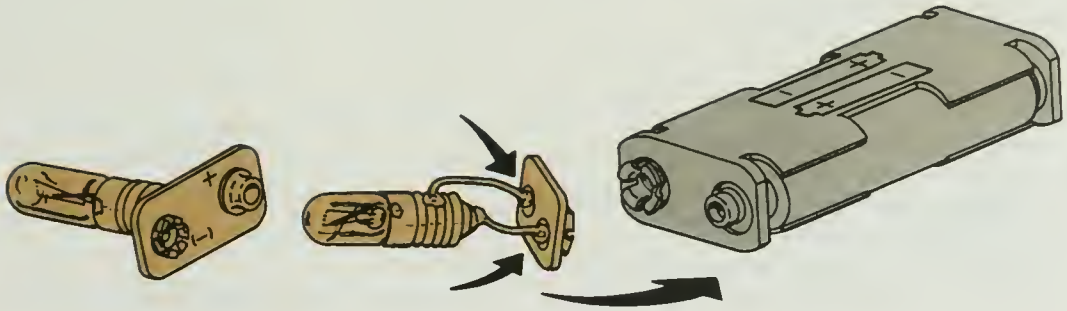
Build a Battery-powered Mini-beacon

You can assemble this blinker in minutes. Use it to mark your car when you leave it in a crowded lot, or put it in a window to identify your house for evening guests

THE NIGHT IS DARK, rain is falling and the parking lot is full. The problem: how to find your car. That's easy—right over there under that twinkling star! Well, it's not a star, but one of those 3-volt thermal-blink lights found in many children's toys.

You can also build a blinking light for your doorway or driveway if all the houses on your street are similar. This way visitors can look for the twinkling star and find you with no problem.

Solder the bulb directly to a terminal strip pulled from a defective transistor battery. Next snap it to a two-cell battery holder that mates the snap terminals on the battery strip. It's that easy. C cells will do, but anything larger will be better and last longer. You can cement an alligator clip for fastening purposes.



Making Emergency Repairs while Afloat

With planning and imagination, you can get any boat back to shore safely

THE KEY TO HANDLING an engine failure or sudden damage to the hull is advance preparation. True, you never know just what sort of an emergency may occur, but if you know how to handle the most common breakdowns, the chances are you'll make it back home—or at least to shore—under your own power.

First, one should review engine emergencies. Start by making up a box of spare parts and assembling an adequate tool kit. It does not help to know what to do if your tools and parts are back home, so keep them in a convenient spot aboard the boat; a spot that is dry and easily accessible.

Parts you should include are spark plugs, coils, condenser, points for the distributor, rotor, distributor cap, and a fuel filter. If your power is outboard, you will need the plugs and an extra fuel line assembly. Other items in the "it's a good idea to have" category are belts, water hoses, hose clamps, and a spare propeller.

Tools to be carried include an adjustable end wrench, vise-grip pliers, slip joint pliers, pipe wrench, box-end wrench set, regular and phillips head screwdrivers in various sizes, and a hammer. Add a plug gap gauge of the correct size for your plugs, a set of feeler gauges for the points and a test lamp of the same voltage as your boat's electrical system. Your engine manual should also be carried; it's the most valuable tool you can have.

Most engine breakdowns are the result of a failure in the electrical system. Here are some common failures, their symptoms and how to locate and correct the trouble.

If the starting motor does not operate, turn off all electrical equipment and wait for about 30 minutes for the battery to recover. While waiting, check the cable connections at the battery terminals. Don't just look—remove the clamps, clean the posts, then reclamp.

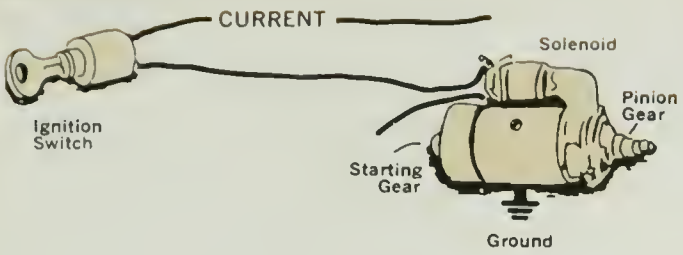
To check a defective starter switch, make sure that all connections are tight, and that there are no broken wires or bare wiring touching the engine frame. Use the test lamp by placing one lead to the ground post of the battery (the one connected to the engine frame or block), and the other test lamp lead to the primary terminal (small wire connection) on the distributor. When the engine is cranked over by hand, the lamp will light when the distributor points are open if the ignition switch is in the "ON" position and working properly.

If the starting motor operates but will not engage, loosen the starting motor from the engine by removing the attachment bolts. Check the small pinion gear to see if it is stuck on the shaft. If it is stuck, free it with a hammer and oil it with a few drops of oil from the engine dip stick.

Before attempting any electrical repairs as outlined, make sure bilges and engine compartment are rid of any explosive vapors!

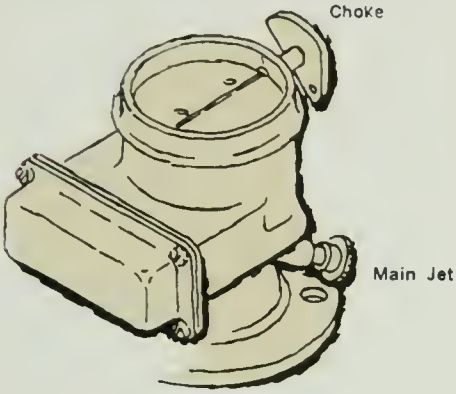
If the starting motor operates but the

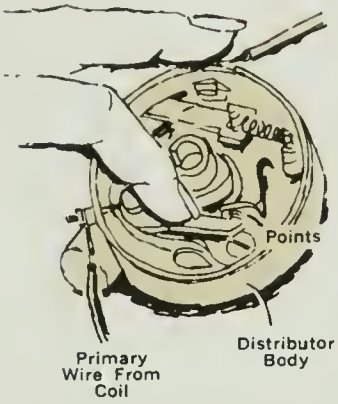
emergency brakes: see disc brakes
emergency shelters: see survival
emery: see abrasives

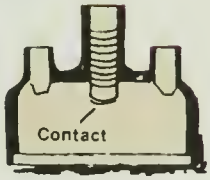


In checking a delective starter switch, leave Ignition switch on and connect a test lamp to battery and starter solenoid.

The carburetor should be checked if starting motor is working and the spark is good but the engine still will not start.

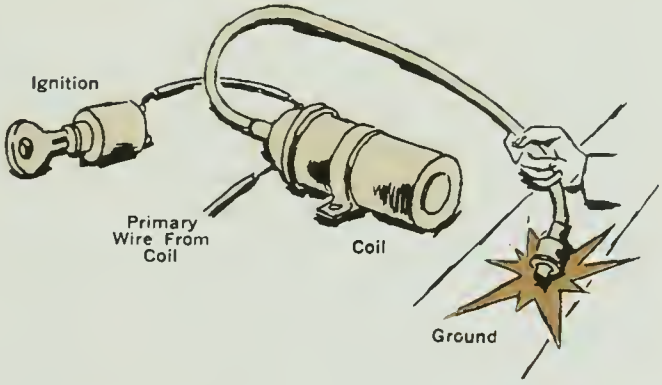


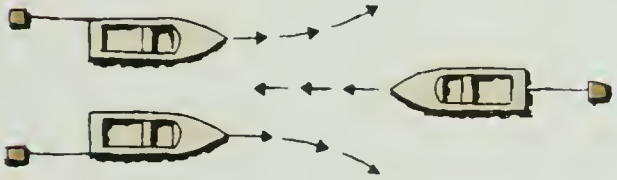




Distributor points should be checked if the starter motor is operating but the engine will not start. If the points are opening and closing as the engine is cranked, they are working properly.

In case of complete electrical failure, connect a length of wire to battery positive and start engine by grounding small terminal on starter solenoid with screwdriver.





If the rudder is inoperative for any reason, you should put a bucket behind the boat; by shifting the lines from side to side, you can control the direction of the boat.

engine will not start, check the small wires that make up this circuit. Look for corroded, dirty, damaged or loose connections. This includes the wires from the junction box to the ignition switch, the wire to the coil, and to the distributor.

Look for broken or damaged wires to the spark plugs and from the coil to the distributor cap. There may be moisture on the plug wires that actually ground out the spark voltage before it reaches the plugs.

Check the distributor points to see if they are opening and closing as the engine is cranked. Stop the cranking when the points are at the maximum open position. Use the feeler gauge for the gap specified in your engine manual, if it is necessary to adjust the gap. In an emergency, a match book cover may be used as a feeler gauge to check the gap.

Inspect the distributor cap to see if the contact button is in place and moving freely. This contact carries current from the coil to the spark plugs and must make contact with the rotor. Also inspect the cap for cracks and excessive corrosion on outer contacts. Check the rotor tip for excessive corrosion and wear. Do *not* attempt to file away corrosion on the rotor tip. Replace the distributor cap and/or rotor as necessary. Be sure to replace spark plug leads in the correct sockets.

Hold a spark plug wire about ¼-inch from the engine block while cranking the engine over with the ignition switch on. Do *not* hold the wire in your bare hand! You can get a severe jolt from the current that leaks through the insulation. If a spark jumps from the wire tip to the engine, the trouble may be with the spark plugs themselves, or the fuel system. If there is no spark, remove the secondary lead from the center terminal of the distributor cap, and check it in the same manner. Do *not* hold the wire in your bare hand; use a heavy, dry, clean cloth as insulation. If you get a spark, the trouble is in the distributor cap or rotor. If there is no spark, the trouble is in the ignition primary circuit. Check as outlined above.

An overheated engine might not start. Allow it to cool. Check for leaks in the cooling system and pump operation to avoid further overheating.

If the starting motor operates and the spark plug is good, but the engine will not start, make sure there is fuel in your tank(s). A good rule is never to cruise farther than where one-third of your fuel will take you. That gives you two-thirds to get home on, and if you're bucking strong headwinds or currents, you may need it.

See if the fuel filter or sediment bowl is filled with fuel. If it is not, and your tank is full, check to see if the fuel shut-off valve at the tank has vibrated closed, or if a fuel line is clogged. Disconnect the inlet side of the pump, and blow through the line. Look for dents in the fuel line, and air leaks in the pump gaskets or in fuel line connections. Make sure the gasoline tank vent is open.

To check the carburetor, remove the sediment bowl from the fuel pump to make sure the screen is clean; a clogged screen will prevent fuel from reaching the carburetor. Disconnect outlet line from the pump, and pull the secondary (heavy) wire from the coil to make sure the ignition system is dead. Then crank the engine and see if fuel is pumped out of the outlet line. Be sure to use a container to catch this fuel, and pour it back into the tank. Mop up any spilled fuel and dispose of the rags in a safe manner.

In checking the cylinder, make sure fuel/air mixture is reaching the cylinders. Remove the spark plugs and see if they are moist. If they are dry, fuel is not getting to the cylinders. Many marine carburetors have a main jet adjustment that can be turned to increase the fuel flow.

DISTRESS SIGNALS

Distress Signal	Rules of the Road or Pilot Rules			
	Inland	Great Lakes	Western Rivers	International
Continuous sounding with any fog-signal apparatus	D/N	D/N	D/N	X
Firing of a gun or other explosive signal	D/N	D/N(2)	D/N(2)	X(2)
Flames on the vessel (as from a burning tar or oil barrel, etc.)	N	N	N	X
A square flag having a ball, or some object resembling a ball, either above or below it		D	D	X
Slowly and repeatedly raising and lowering arms outstretched to each side	D	D	D	X
Rockets or shells, throwing stars of any color or description, fired one at a time at short intervals		N	D/N	X
The International Code signal of distress indicated by NC			D	X
The signal SOS sent in the Morse code (... — — — ...) sent by any means				X
The spoken word "Mayday" by radiotelephone				X
A rocket parachute flare or a hand flare showing a red light				X
A smoke signal giving off a volume of orange colored smoke				X

The above signals can be used singly or in any combination.

Note: 1—D = Day use; N = Night use; D/N = Day or night use; X—IntRR do not specify in terms of day or night use.

2—Fired at intervals of about one minute.

Make sure the choke is closing properly. This is especially important on dual carburetors because if the linkage permits one choke to remain open, both will be out of service.

If your spark plug check reveals plugs that are soaked with fuel, it indicates flooding caused by using the choke too long. Open the throttle all the way, and put the choke in the open position. With the ignition on, crank the engine several times; this draws nothing but air through the cylinders. With an inboard, after about 20 or 30 seconds of cranking, the engine will start. If an outboard's plugs are fouled by flooding, remove them all, clean them, and turn the engine over several times with the plugs *out* in order to clear excess fuel from cylinders and crankcase. Be sure the flame arresters are in place before cranking any engine.

Most emergency repairs can be made with material you have aboard your boat. With a little imagination, you can make almost anything you need in order to get under way. Here are some jury-rigs that have actually worked:

Broken fan belt. If necessary, a replacement fan belt can be made from a rope or piece of line that's thin enough to fit in the pulleys. Simply tie the line as snugly as possible around the pulleys, securing the ends with a square knot. Adjust the moveable pulley so there's no slack in the line.

Operate the engine at a slow speed, and check your new belt frequently.

Broken pipe or hose. Bandage the break with rags, plastic electrician's tape, canvas, dacron, or any other suitable material. Lash the bandage in place with line, or even your belt.

Lost or damaged rudder. If your rudder breaks loose, jams, or becomes inoperative, use a bucket behind the boat. By shifting the line from side to side, you can control the direction of your boat.

Engine oil leak. Catch the oil in a pan or bucket, and pour it back into the engine. Keep repeating as necessary.

Complete electrical failure. To get the engine running, disconnect all electrical equipment from the battery except the large cables from the battery to the starter. Connect a length of wire from the battery positive post to the coil primary switch side. Start the engine by grounding the small terminal on the starter solenoid with a screwdriver. To stop the engine, disconnect the wire from battery to coil.

The circumstances of suddenly taking on water are so varied as to permit only the most generalized advance planning, but in most cases the following steps may be effective:

Switch on all bilge pumps. The risk of harm to pumps by running them dry is far less than that of having water in the bilge get a head start. Turn pumps off as soon as they are not needed.

Manual bilge pumps. Assign crew members to operate these, as necessary.

Inspect for leaks. Assign a crew member to check for leaks; pull up floorboards as necessary to check the bilges. Check all intake and outlet hoses and seacocks.

Damage control actions. In most cases, boat should be slowed or stopped to minimize inflow of water. In some cases a hole may be kept above water by remaining on plane. If manual and regular pumps do not control the influx of water, stop your engine, shut the water intake seacock and transfer the water intake line to the bilge. Restart the engine so its water pump is also drawing water from the bilge. There must be enough water in the bilge to meet the engine's cooling needs, and caution must be exercised to prevent debris from being sucked into the cooling system.

If possible, cover the hole from outside the boat using canvas, bunk sheets, blankets, towels, seat cushions, or any other material available. Lash or nail it in place. It may be possible to nail boards over the hole, or a piece of tin from a can, to reduce leakage. On fiberglass or aluminum hulls, bend or clinch the nails on the inside of the hull to prevent the patch from falling away from the hull. Sometimes it is possible to wedge a cushion against a hole from inside the boat. The object is to restrict the inflow of water into the boat to a rate that can be handled by your pumps.

Call the Coast Guard. If you have a radiotelephone, call the Coast Guard and let them know your location and condition. If the situation is critical, and you realize you cannot keep the boat afloat, give the "Mayday" call on your radiotelephone, and display one or more distress signals.

If you must abandon your boat, have everyone stay together and keep calm. Use a length of rope to connect everyone together facing each other. This position will give the most buoyancy, and it will help keep the group warm and in good spirits until help arrives. Be sure each person is wearing a proper personal flotation device.

Most boats will not sink completely; instead they will reach a point of equilibrium with the decks awash, or capsize with the underbody remaining on the surface. Stay with the boat until help arrives. Not only will you have something to hang on to, but you will be more easily spotted by searchers.

See also: BOAT ENGINE; BOATING.

An Easy Way to Enclose Your Bathtub

In less than an hour, you can add new elegance to your bathroom with a plastic folding shower door

After measuring distance between walls along rim of tub and top of enclosure space, use hacksaw or coping saw (with metal-cutting blade) to cut aluminum tracks.

WHETHER YOU ARE planning to remodel or redecorate your bathroom, it will take you less than an hour to install a functional and highly decorative tub or shower enclosure, available as a kit.

Fashioned of flexible plastic, the folding doors are mounted on durable, anodized aluminum. When folded back, they are less than 8 inches wide. The panels are shatterproof and safe, with none of the dangers associated with glass enclosures. The injury-accident rate in the bathroom is cut way down because the translucent folding panels will not break or crack and can't cut, scratch or bruise the user. Ease of maintenance is another plus—the enclosure cleans with a wipe of a damp cloth, and the panels will not mold or mildew.

The watertight door is especially welcome in homes where small children happily splash while bathing. It conveniently permits opening or closing from either end, for complete freedom for bathing children and easy cleaning of the tub.

The doors are individually packaged, and all necessary instruction, hardware and mastic are included. No custom fitting is necessary. The doors are available in twelve sizes to fit any opening. Installation procedure for the enclosure is as follows:

Measure the distance between the walls along the rim of your tub or shower threshold; also measure at top and cut the aluminum bottom track and top track with a hack saw (or a coping saw with a metal-cutting blade). The track should be cut ½-inch shorter than this measurement.

Lubricate the tracks with a silicone impregnated swab (provided in the kit).

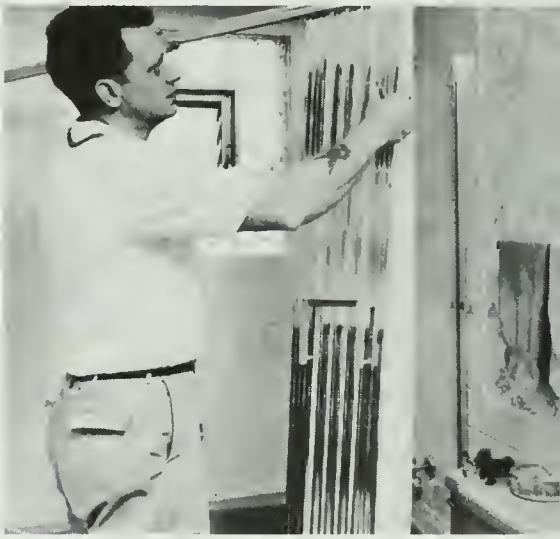
Screw or glue the wall sections in place (screws and mastic provided). Mark holes in wall through indicated holes in both wall sections, making sure they are vertical and touching tub and wall surfaces equally.

Slide the center section onto the top and

end grain finishing: see woodworking
end grooving: see drill press
end table speakers: see stereo
energy: see fuels
energy efficiency ratio: see air conditioners

Screw or glue wall sections in place.

Lift the sliding door assembly, including top and bottom tracks, and insert into either wall section. Carefully lift bottom rail into opposite wall section by cocking entire unit.



Slide the center section onto the top and bottom tracks.

bottom tracks. This can be done by laying the door on a flat surface or standing it up. These tracks are not open and sharp-edged. No dirt can collect—cleaning is a breeze.

Lift sliding door assembly, including top and bottom tracks. Insert entire unit into either wall section. Panels should bow into tub. Keep center sliding section of the door at the end just inserted. Carefully lift bottom rail into the opposite wall section by cocking entire unit. Top track will then lift in easily. Entire unit is now in place. Lift the unit so the top track can rest on the top of the wall section while you squeeze a ribbon of mastic below the bottom track along the entire width of the tub, so that the bottom track will be sealed to the tub. Drop the door into mastic.

Install long snap-in moldings in aluminum wall sections. If for any reason it becomes necessary to remove the door, the snap-in moldings can be pried off without damage. Handles and latches, as well as push button locks on the wall sections, may be installed before or after the door is in place.

See also: BATHROOMS.

An Easy Way to Enclose Your Bathtub 981

Install the snap-in moldings in aluminum wall sections.

The folding door is available in a variety of soft colors to blend with any decor.

Cut Down on Gasket Replacements

Faulty gaskets are very rare. Correct application cuts down on replacement and gives you a cleaner engine and better gas mileage

MANY GASKETS, particularly engine cylinder head gaskets, "blow." Maybe it has happened to you, and maybe you thought the fault lay in the quality or construction of the gasket. Actually, gaskets usually blow because of incorrect application. It is the way you do or do not prepare the surfaces to be sealed together that counts, and counts heavily. The gasoline mileage you get, the engine's cooling efficiency, compression, lubrication, silencing of the exhaust, tightness of the rear axle housing and other performance factors depend on the ability of gaskets to seal well; to maintain pressure; and to keep out dirt and water. The oil, water or fuel that drips on your garage floor overnight may indicate leaky gaskets. The leakage may be worse when the car is running because parts get hot, metal expands and the gasket-packed joints widen, creating greater leakage. If you want to track down guilty gaskets, first inspect the car's engine carefully. If you see rusty and gooey-looking seepage around the cylinder block and head joint, your engine needs a new head gasket. The same evidence around the crankcase and oil pan joints, the water inlet elbow flange and head, the fuel pump connection to crankcase, the front end chain housing cover, and the water pump flange and manifolds is a sign that gasket trouble has arrived.

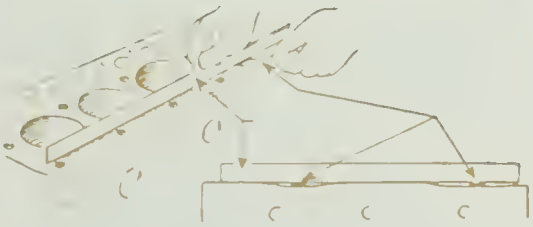
It is always a good rule to install a new gasket every time a joint is opened. The old gasket might "look good" but it has done its job even if it has not "blown," so toss it out and use a new one. There is always the temptation to use the old cylinder head gasket, for example, especially if it comes off clean, stays flat and has that nice shiny copper color. But you cannot reseal the joint adequately with the old gasket. In the first place, the joining surfaces between the cylinder block and head, while "milled" to substantially smooth surfaces, are never completely smooth. Under a microscope, you see a lot of hills and

engine analyzers: see electronics
engine bearings: see bearings
engine, boat: see boat engine
engine oil: see oil, engine
engine parts: see parts replacement, engine

valleys. When the head is bolted down tightly, the copper of the gasket (usually made of asbestos between two thin layers of copper or steel) squeezes into the tiny imperfections of the metal and with the asbestos filler makes a tight seal against compression and coolant losses. Obviously, this compression of the gasket flattens and conforms it to irregularities of the block and head, so that if the head is later removed, it is practically impossible to replace the gasket (which has lost much of its compressibility) and get a perfect seal against all the little irregularities again.

Also, the old gasket may be bent while removing it so that the asbestos filler breaks when the gasket is straightened for reuse—and the gasket is liable to burn through at this weak spot and lose its effective seal.

Cylinder head gaskets. You can find out whether you have a broken and leaky head gasket by checking these points. If the coolant boils at normal atmospheric temperatures and your radiator takes a lot of water, it could indicate a broken gasket. When you make a cylinder compression test and find two adjacent cylinders reading much lower than the others, the gasket may have blown at the spot between the two cylinders. Sometimes you can see bubbles in the top of the radiator, which can be from a blown gasket. An inexpensive air hose adapter is available that threads into the spark plug hole. You can use it to find out whether the head gasket is faulty and allowing leakage into the coolant. To use it, fill the radiator to the top with coolant, run the car until it reaches normal operating temperature, then remove the spark plugs and test each cylinder in this way. Take off the distributor cap so you can watch the rotor. Turn the engine slowly (with fan belt or by jacking up one rear wheel with the transmission in gear), until the rotor is lined up with one of the cap electrodes if the cap were in place. The valves of that cylinder will then be closed. Screw the tester into the spark plug hole of that cylinder and from a hand pump or air supply, apply air to the tester valve. If there is gasket leakage you can see or hear the bubbles at the radiator neck with the filler cap off to allow you to look in.

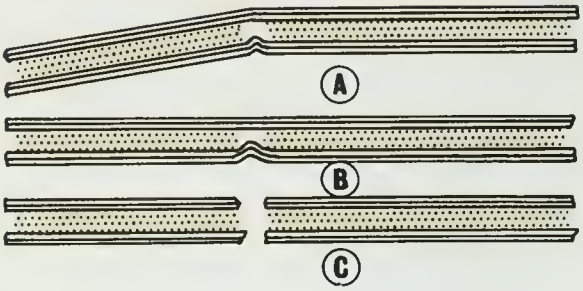


Checking block with a straightedge and a feeler gauge. Same procedure can be used for cylinder head gasket surface.

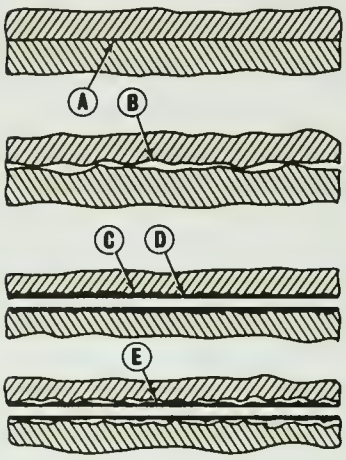
To replace this gasket, you will have to strip the engine of such parts as the air cleaner, carburetor, spark plugs and wiring harness, perhaps the oil filter bracket, the hose connection at the water inlet elbow and other parts depending on the make and type of engine. Then you take out the head bolts or loosen the nuts on the block studs so you can lift off the head. But before you loosen the nuts and bolts, let the engine cool to the surrounding temperature of the atmosphere or room.

Next, clean the block and cylinder head of all carbon deposits by scraping, wire brushing, and with a metal parts cleaner. You can use an ordinary hand tire pump to blow out any foreign matter on the piston heads, bolt holes and water passages. Also, blow out the passages inside the cylinder head to prevent any carbon particles from dropping on the new gasket (such particles can form pockets in the gasket and cause leakage). With the block and head surfaces clean, check the surfaces with a straightedge for indications of distortion or warping.

Since the cylinder head gets hotter than the block, warpage is more likely to occur in the head. If you run into such a condition, it is best to have an automotive



If a cylinder head gasket of the copper asbestos type is bent, the asbestos filler may break (A). If the gasket is then straightened (B), it may look all right, but later burn through and "blow" at the break in the asbestos (C).



Instead of an unobtainable perfect joint (A) between the machined surfaces of a cylinder head and engine block, there is a series of microscopic hills and valleys (B). Note how the metal of the gasket (C) fills the irregularities of the block and head, making a tight joint. (D) is the asbestos filler. After a head gasket has been compressed, it is almost impossible to seal the irregular surfaces (E) again.

machine shop true the surface of the head on a surface grinder. This removal of metal, however, should be held to a minimum as it increases compression ratio—perhaps more than is good for the engine. On old engines, especially, if the cylinder has been re-machined more than once, it is wise to replace the head with a new one.

Make a careful inspection of the cylinder head studs in the block (or the bolt holes, if the head is held down with bolts). If you find there is a buildup of metal around the studs or bolt holes, you can use a chamfering tool to trim enough off so the studs or bolts can be firmly tightened with clearance for the gasket. But make sure you do not remove too much metal with the chamfering tool, particularly where a stud is located very close to two cylinders (removing too much metal in such places may cause gasket to blow). Some mechanics prefer to dress the block with a large file, which also removes the rough spots.

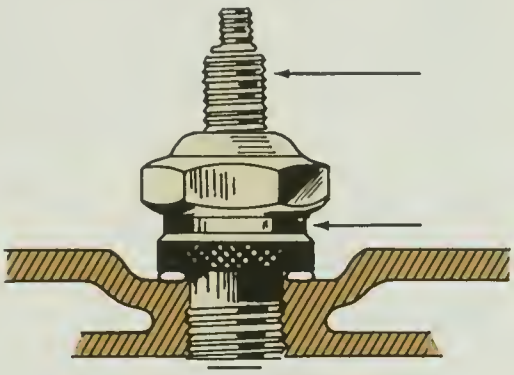
Now check the new gasket for correct fit on the cylinder block. Some gaskets are marked "Top," "Front" or "Up." Check for these markings before installing and follow the directions they indicate. All of the water holes and bolt holes should tally with those in the block. On some engines like the older 6-cylinder Ford, be sure that the gasket is positioned with the cut-off corner at the left front corner of the cylinder block; otherwise water will leak externally at the left rear corner of the engine between the cylinder head and block. Never enlarge any of the water passage holes in the gasket, as the rear cylinders might overheat. Watch out for a bent gasket. The method of applying the gasket depends on the type of gasket material. The steel and the asbestos head gaskets usually have a sealing coat put on them by the gasket manufacturer. This clear coating ordinarily does not require any additional gasket cements. But if this type of gasket does not have a coating you can use a non-hardening gasket compound. This is a liquid material applied with a brush which changes in a few seconds to a paste. It produces a non-drying elastic, adhesive, heat-resisting seal. You can also use it with copper asbestos gaskets.

If you wonder why both steel and copper

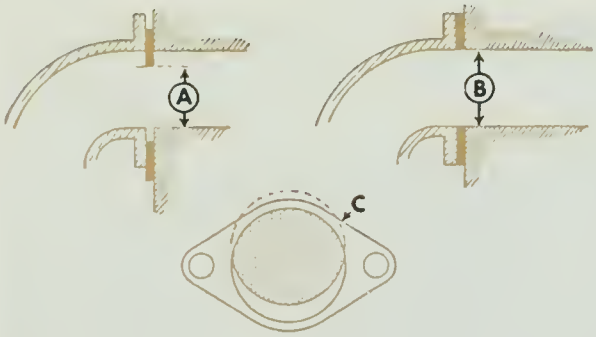
asbestos gaskets are used, each has certain advantages. For example, where high octane fuel is used and detonation is likely, steel resists breakdown better than copper. But this advantage is offset to some extent by the superior heat conductivity of copper. Copper also makes a better seal with less likelihood of compression leakage that might cause burning of the gasket back of the edge of the cylinder opening. Steel has a natural tendency to corrode when exposed to the coolant at water holes or where the gasket itself is exposed to the coolant. Some steel gaskets are made with copper grommets at the water holes. Remember, however, that gaskets with copper ferrules must never be used with aluminum heads.

Some cars use an embossed type of steel cylinder head gasket. This is said to provide an even and uninterrupted flow of heat between the cylinder head and engine block. The design and formation of the embossing makes the flow of metal under compression even, producing a good seal.

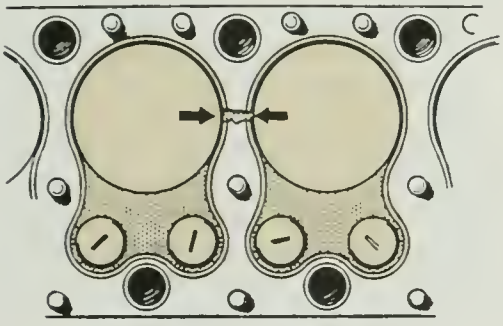
If you do not want to blow your new gasket, better check for clearance of the new gasket around the cylinder bores. The engine may have been rebored and fitted with oversize pistons. In this case, the edge of the metal around the gasket might be very close to, or even slightly overlap, the cylinder bore openings. Thus, on the upstroke, the pistons might strike the head of the gasket, causing early gasket failure or blowout. The minimum clearance from the edge of the gasket to the edge of the cylinder bore opening should be $\frac{1}{32}$-inch. This permits correct gasket compression and prevents direct flame contact burn-out. If



A handy tester to check for a blown gasket can be made by brazing a tire valve into a spark plug shell. You also can isolate a blown head gasket of the two-adjacent-cylinders type by compression testing. If you prefer the air pressure test, but have no brazing equipment, you can buy the equivalent of the plug shell and tire valve tool at auto supply stores.



Intake and exhaust manifolds must have their gaskets in alignment; otherwise the port openings are reduced. Note the small opening (A) compared to what it should be (B). The effect of misalignment on port opening is shown at (C).



Occasionally a cylinder head gasket breaks at a point between two adjacent cylinders, shown by the heavy arrows.

you find you cannot get this clearance, check the tops of the pistons for a number such as +.010 which indicates an oversize piston, and buy a gasket to match it.

Make a final check to make sure that the gasket is correctly centered. If the head is held by studs, this is easy. But if long cap screws or bolts are used, buy a couple of longer bolts, cut off the heads and screw these into a couple of holes at the end of the block. These will serve as pilots. After the head has been dropped and a half dozen or so of the head bolts inserted finger-tight, remove the pilot bolts with pliers.

You are now ready to tighten the head, which must be done with a torque wrench, to factory specifications.

After you have replaced the accessories you previously removed, run the engine for 15 or 20 minutes at a fast idle and then go over the head bolts on the cast-iron head again, once more tightening them about a quarter turn. On aluminum heads, the engine must first be cooled to room temperature before tightening the bolts down. You should tighten again after about 300 or 400 miles of operation, using the same recommended sequence.

Manifold gaskets. When you install intake and exhaust manifold gaskets, alignment is important. If the gasket does not line up with the port holes, the reduced port opening area cuts down on engine power and, in the case of the exhaust, might cause engine overheating. On manifold gaskets, the gaskets are positioned by the bolts holding the manifold on the head. On overhead-valve V-8 engines, tighten the bolts holding the intake manifold. If they are loose, air is pulled into the manifold, making a lean mixture, and also ruining the gasket.

Intake manifold gaskets are additionally important on some V-8 engines, where they seal off the valve tappet chamber. A poor gasket seal in such a situation could cause the engine to leak oil.

Other gaskets. Although the cylinder head and intake manifold gaskets involve a great deal of work and care, there are other gaskets that are more prone to failure. These include the rocker cover, oil pan, fuel pump, thermostat housing, timing chain cover, rear axle cover, and transmission pan.

There is nothing complicated about gasket replacement, but unless you do it correctly, you can find yourself with an expensive comeback. Clearly, a gasket is supposed to seal, and if it leaks, something is wrong.

To insure a leak-free seal, regardless of what gasket is being replaced, takes just a bit of care and know-how.

Start by making sure that if the bolts that hold the cover or part are of different lengths, you know exactly where they go, so you can refit them properly. A simple technique is to push them through a piece of cardboard in the pattern that they go on the engine or transmission.

Note that some of the bolt holes in this transmission oil pan have gasket residue. It must be cleaned out (also gasket surface and pan itself), before fitting a new gasket.

➤ *Minor irregularities in a pan or rocker cover can be straightened with a hammer and the pan or cover on a flat surface, such as a block of wood.*

➤ *If a cork gasket has shrunk, it can be soaked in warm water.*

When you remove the cover, pan or part, scrape all gasket particles from both gasket surfaces, using a scraper. A screwdriver often will do the job, but it is a blunt instrument and you may gouge a gasket surface using it. This is particularly true of an aluminum part, such as a thermostat housing. Aluminum is quite soft and it does not take much to damage it.

On sheet metal parts with a narrow groove in the gasket surface, however, a thin screwdriver is about the only practical way to clean the groove, particularly if the gasket is cork or if a coating of sealant was applied.

Cleaning out gasket material from bolt holes is very important. Pieces of gasket material can prevent the bolt from seating properly. Remove large pieces with an awl and blow out small pieces with compressed air.

At this time, inspect the bolt holes. If any go through to water jacket or oil passage, the bolts will have to be coated with thread sealer when you reassemble.

Once the gasket surfaces are absolutely clean, you can fit the new gasket.

There are four common choices in gasket material for sealing fluids under low pressure: cork, composition cork, neoprene and treated paper.

Treated paper has little resiliency and does a relatively poor job of compensating for any warpage in parts. It should not be used except in emergencies when nothing else is available.

Cork has been a popular gasket material for many years. It does a fine job of compensating for irregularities in sealing surfaces, but it is somewhat brittle and it shrinks when stored in a dry place for some time.

Composition cork is a combination of cork and other fibers. It is less brittle than cork, less prone to shrinkage, and is almost as resilient.

Neoprene is the best material. It is the easiest to handle, does the best job of sealing, doesn't shrink and doesn't break. If you can get a particular gasket in neoprene, this should be your choice.

Unfortunately, you do not always have a choice. Some gaskets for certain cars are only available in cork, or composition cork, or perhaps just treated paper.

If a cork or composition cork gasket has shrunk, do not try to force it in place, or it will probably break. Soak it in warm water for fifteen minutes and it will stretch to properly cover the gasket surface.

If the old gasket was leaking badly, don't just install a new one. See if the gasket flange is distorted by lining up a straight edge against it.

A mildly-distorted flange can be straightened with a hammer, as illustrated, by holding the flange against a flat wooden surface. Do not try to straighten one that is badly cocked; replace the part.

Many pans and covers have retaining features for the gasket, such as cutouts for gasket tabs. With such designs, a sealant is frequently unnecessary.

If a sealant is necessary to hold the gasket in place, or to provide additional sealing for a hard-to-seal surface, only apply the sealant to the cover or pan, not to the engine or transmission. That pan might have to come off again some day, and if the someone who has to do the job is you, you won't want to scrape sealant and gasket off two surfaces.

Gasket shellac is a glue that will keep a gasket from shifting position during installation in a tight spot. It is not as good a sealant as the flexible setting type and should be avoided. It certainly is difficult to scrape off completely.

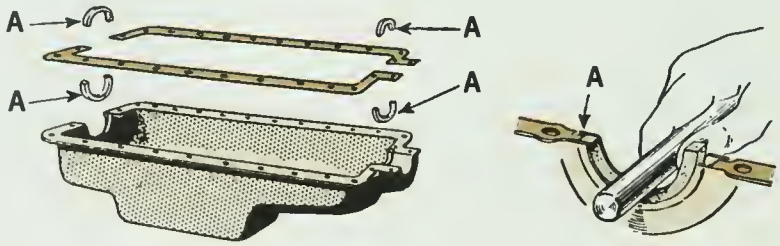
Never overtighten a gasket. Excessive tightening is the major cause of distortion of a cover or pan. If a leak won't stop with a new gasket, coating of sealant, and tightening to specifications—something is wrong, probably a warped pan or cover.

Do not leave out the bolt washers. Many pans and covers rely on the washers, which often are specially shaped, to distribute the bolt tension evenly and contribute to a good seal.

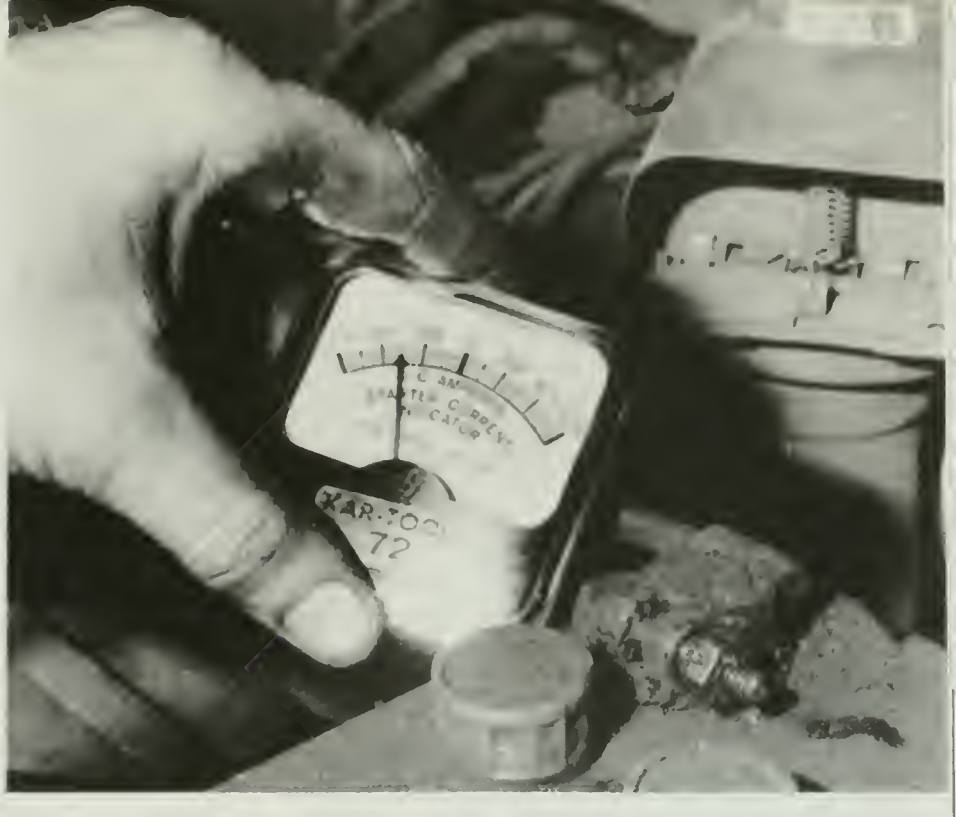
You can buy sheet cork and treated paper and make your own gaskets. This procedure is recommended for emergency use only. Gaskets are cheap, and although with care you could make one that is almost as good, you also might not.

On many cars, replacing the oil pan gasket is anything but easy. To avoid removing the pan, which requires jacking the engine well up off its mounts for clearance on many cars, you will be working in tight quarters with the oil pan hanging down just a few inches. Be sure you take the time to scrape off the old gasket completely, clean the side packing grooves and check the mating surfaces in the engine for any burrs, which can be smoothed with an oil stone if not deep. P.W.

See also: PARTS REPLACEMENT, ENGINE.



Engine oil pans usually have two cork gaskets. When they are replaced, the crankshaft oil seal packings (A) should also be replaced, as illustrated. The oil seal packings should be rolled in place.



This little induction ammeter measures starter current draw when clamped onto battery cable while engine is cranking. Note reading of 350 amps, which is excessive.

How to Revive a Faltering Starter

Despite their reliable reputation, millions of starters require servicing each year, but most of this repair can be done in your own garage at a real savings

EVEN THOUGH THE STARTER motor seems to be the most reliable part in an automobile, and many car owners have found it to last the life of the car, statistics reveal that millions of starters are replaced each year.

Also, there are many possibilities of failure within the entire starting circuit, so when all starting problems are totaled they run into the tens of millions. A significant percentage of these are characterized by complaints like "the engine is not cranking" or "it is turning over too slowly."

The no crank solution is usually found in the electrical feed to the starter—a weak battery, loose or corroded cables. A simple test is made with a hydrometer, an inexpensive and easy to use instrument.

If you are a reasonably careful weekend mechanic, the problems associated with a weak battery or bad cable connections will probably be part of routine maintenance.

A common cause of slow cranking is the use of heavy engine oil in the winter. This creates so much drag that the starter cannot overcome it. Many people start out with a light oil, such as 5W-20 or 10W-30, but they add a can or two of oil additive, which is a thickener. A couple of cans of oil additive in a normal crankcase can turn a 10 weight oil into a 30 or 40 weight.

The remaining possible problems are with the starter itself or with some special switches. The most common difficulties are well within the ability of the weekend mechanic to trouble-shoot and correct.

The parts most likely to give trouble in the area of starter and special switches are:

Starter solenoid. This is an electromagnetic switch built into a hump on top of the starter. When energized, it permits battery current to flow into the starter to motorize it, and it actuates a fork that pushes the starter's little drive gear into mesh with the flywheel ring gear to crank the engine.

Starter brushes. The typical starter has four brushes which are soft metal contacts with the armature, a wired shaft that spins to impart power to the starter drive gear. Each brush is part of the circuit that keeps the armature spinning. When the brushes wear down, the springs that maintain tension against the armature are fully extended. The brushes may make irregular contact thus impeding current transfer.

▲ *Solenoid is easily removed from top of starter. Just take out the screws or bolts, then lift it up and out.*

➢ *On some starters, solenoid must be twisted before it can be removed. Twisting unlocks flat tang (to left of screw hole on solenoid).*

Starter drive gear assembly. The drive gear is subject to damage to gear teeth, to the clutch mechanism that disengages it when the engine starts, and with the splines along which it rides to engagement, to rusting.

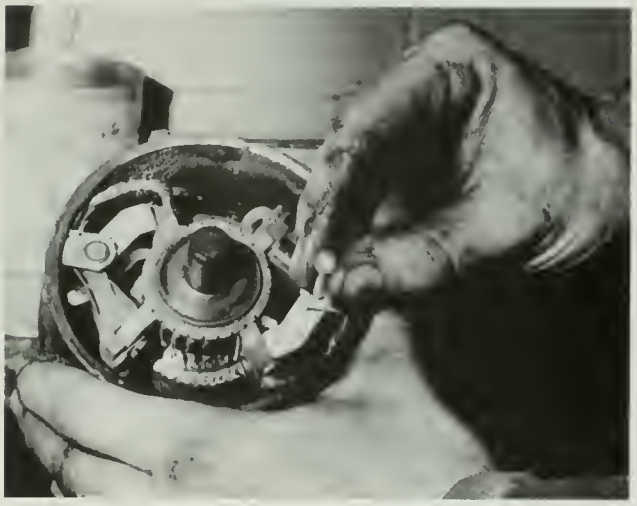
Neutral safety switch or clutch switch. The reason you can only start an automatic transmission car with the shift lever in certain positions, and some clutch cars with the pedal depressed, is that a special switch is incorporated into the starting circuit. This switch only completes the starting circuit when the shift lever or clutch pedal, is properly positioned. If the switch fails, the car will not start regardless of positioning.

Starter relay. On most Ford products and some Chrysler cars, the starter relay is a switch mounted on the body sheet metal in the engine compartment. It is a convenient gathering point for the action of the special switches, and as an example, it can be triggered by the automatic transmission switch, or by turning the ignition key on. When the relay is actuated, it permits current to flow to the starter solenoid.

Normally these special switches and relays are reliable. When they fail, the lo-

To get to brushes, remove the through bolts (two through the starter end plate).

Starter brushes are held in various ways. In this starter, a pin is used. To get brushes out, pull pin, then remove leaf spring that tensions them against armature; brushes can then be lifted up.



cating and trouble-shooting of them should be left to a professional mechanic.

The weekend mechanic is safest limiting himself to troubles in the starter. The quickest way to determine if the problems are in the starter is to listen for a click at the starter solenoid. If you hear it, the problem is in the starter. If you do not, disconnect the wire to the solenoid "S" terminal and run a 14 or 16 gauge jumper wire from the battery cable to that terminal. If you now hear a click (perhaps the starter will even work), there is a problem in the wiring up to the starter. If the solenoid merely clicks, there is a problem in the starter, too, but fixing it will not solve the whole problem.

The most common symptoms of starter trouble are:

1. Very slow cranking.
2. Failure to crank at all.
3. Starter spins, but the engine does not crank.
4. Starter cranks but does not disengage readily when the engine starts.

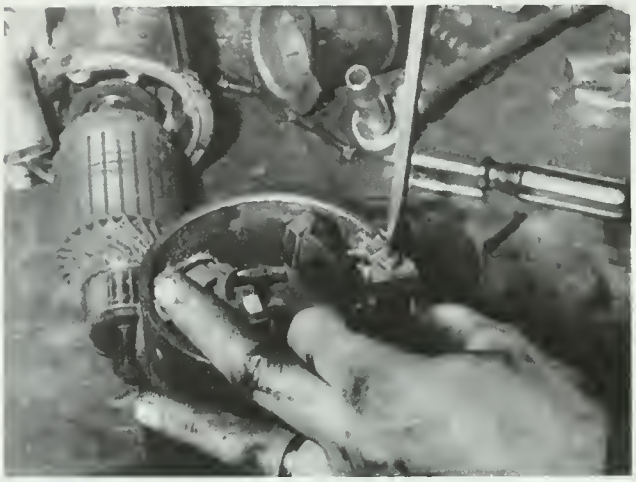
Very slow cranking, when not caused by poor battery connections or heavy oil, may be caused by high resistance in the solenoid, badly worn brushes, binding of the armature and a defect in the armature.

A simple check you can make is to test starter current draw during engine cranking, using an induction ammeter. This little device clamps onto the battery cable to the starter and gives an approximate reading of current flowing to the starter. It is not the most accurate gadget in the world, but it is inexpensive and it can usually pinpoint excessive current draw. If current draw is in the under 200-amp range, it is normal; if it is in the 300- to 400-amp-range, it's entirely too high and something is wrong. Heavy oil or a rebuilt engine that was set up with clearances too tight are the common causes of this. However, there are internal starter causes too.

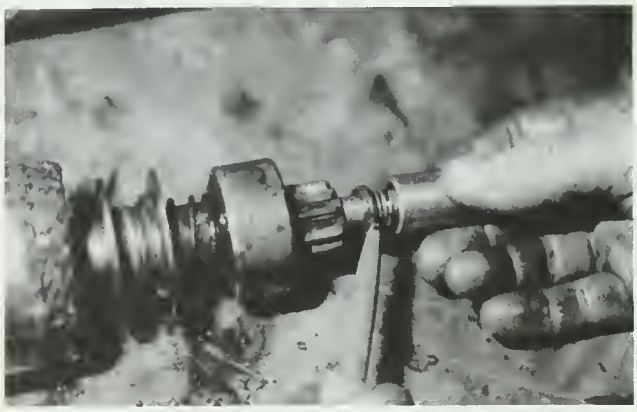
If the current available to the battery is adequate (charged battery, good connections), and current draw is within limits, then slow cranking is most likely caused

by one of these: a defective engine ground (the ground strap from engine to body); high solenoid resistance; worn brushes or an armature defect, such as a wiring break.

Failure of the starter to crank has many causes. If the solenoid does not click, even with the jumper wire procedure outlined earlier, it is apparently defective. If the solenoid clicks, but the engine does not crank, the starter should be disassembled and inspected.



If brushes are badly worn, just unscrew the old and install the new.



Removal of starter drive depends on design. In this particular unit (a Delco), a 9/16-inch deep socket must be used (with a soft-face hammer) to drive a bushing over the snap ring. Then the snap ring is removed and the entire starter drive assembly just slides off.

Starter drive, shown being slid off, is replaced as a complete assembly.

When the starter spins, but the engine does not, there is one likely possibility and some remote ones. The odds are that the drive gear is not engaging the flywheel ring gear, and the exact reason must be determined by starter disassembly and inspection. Also possible are broken teeth on the drive gear or flywheel ring gear, failure of either starter gear to hold on the armature or ring gear to hold on the flywheel.

If the starter will not disengage normally, it is probably a defective solenoid or defective starter drive gear clutch. A defective key switch is also possible. On cars with a relay, the relay is the first thing to suspect.

Removing the starter motor is usually uncomplicated, although in most cases the job requires jacking up the car and working from underneath.

Before you begin, make a simple sketch of all the wires that connect to the starter and solenoid. If terminals have letters adjoining, note the letters (you may have to brush off road film to find them, but they're usually there).

Always support the car on safety stands, unless it is being raised on ramps.

Do not disconnect anything at the starter until you have removed the ground cable from the battery. Now you can get to the starter itself.

A starter is normally held by two bolts through the bellhousing and into the engine block. (Many GM cars have two bolts from the bottom of the starter up into the engine block, and a third on top into an engine block bracket.)

On some cars, it is necessary to take off some part, frequently the oil filter, to gain enough clearance to remove the starter. If you see this problem, drain the engine oil, then remove the oil filter so that you do not get doused with oil when you are under the car.

Pull the starter forward, then tilt down or up to clear nearby components.

Before dismantling, check the starter with jumper cables and a good battery. Connect one cable to a starter body bolt or flange, and to the battery ground terminal (usually the negative post). Connect the other cable from the battery to the thick cable post on the starter. Also run a thin (14 or 16 gauge) jumper wire from the starter "S" terminal to the battery cable post on the starter (note: the starter should be held firmly, preferably in a vise). If the starter now works, the problem is in the car wiring.

If the solenoid does not click, replace the solenoid. Two or three screws hold it in place, and once they are out, the solenoid can be lifted up and out, as shown in the illustrations.

If a worn brush problem was indicated, remove the through-screws from the end plate and pull it off. This will expose the brushes bearing against the commutator section of the armature. The commutator consists of many copper segments separated by insulation. If the commutator is not smooth, it should be removed and resurfaced at a machine shop. Minor burrs can be smoothed out with fine crocus cloth.

Try to turn the armature. It should turn easily and with no signs of binding. If you encounter binding or looseness of the commutator in its guide bushings, get a rebuilt starter.

If the brushes are badly worn, replacing them is not complex. A typical brush mounting and its removal are shown in the illustrations. If you are unsure about the condition of the brushes, and no other problem is obvious, take a look at new brushes, and if the old ones do not seem to be worn to the nub by comparison, get a rebuilt starter.

Go to the front end of the starter and check the drive mechanism. It should move easily on its splines, hold when it gets to the end and turn the armature when you turn it.

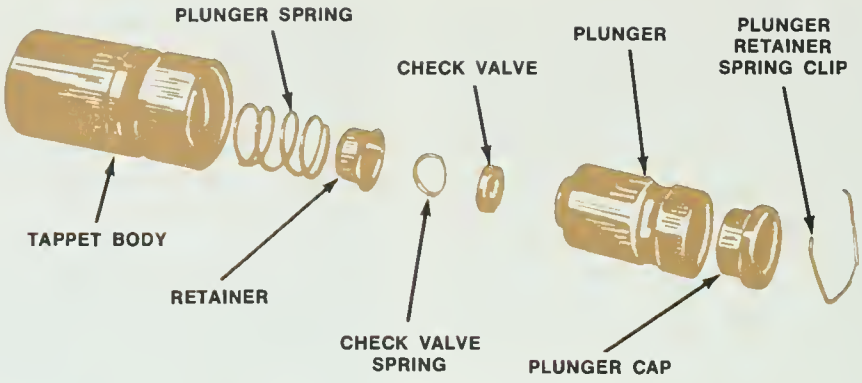
Replacement of a defective starter drive varies according to the make of starter. In the Delco unit illustrated, you have to drive an end bushing over a snap ring, using either a special tool or a $^{9}/_{16}$-inch deep socket. Then pull the snap ring and take off the drive gear assembly.

If the starter cannot be motorized out of the car, it will not work in the car either, so do not try this and then put the starter back in and hope. Always connect a battery to it, as described earlier, to check it out.

Unless a problem is limited to a solenoid, brushes or starter drive, buy a rebuilt starter. This is usually the cheapest way out when anything major is wrong, and very time-saving when the problem is not obvious.

There is no perfection in this world, particularly in the rebuilding of starters. Always ask the parts house from which you are buying the unit to check it out with a battery before you leave. P.W.

See also: ELECTRICAL, AUTO; PARTS REPLACEMENT, ENGINE.



Hydraulic valve lifter disassembled.

Servicing Your Engine's Tappets

Silencing the clatter of sticky hydraulic valve lifters improves engine performance

MANY MOTORISTS with some of the finest and latest cars are plagued by a tapping sound under the hood. This noise may be light or heavy; it may continue for only a few seconds when the car is first started, or it may not clear up for many miles. And, in some cases, the noise may not stop at all.

The sound is probably caused by the hydraulic tappets. These tappets were designed to assure quiet engine operation with maximum power but, when they fail, the result is noisy operation and loss of power.

The lifter rides on the camshaft and carries a push rod which operates the rocker arm, which in turn opens and closes the valve. Strictly speaking, the rocker arm does not *close* the valve. This is done by the valve spring as the cam allows the valve lifter to descend and the push rod and rocker arms are allowed to "retreat."

In any engine there is always the possibility that carbon is causing valve sticking, with resultant noise and loss of engine performance. And, while we are concerned at the moment with the quiet and efficient performance of valve lifters, we cannot ignore valve conditions. It is a good idea on any engine checkup operation to use one of the commercial valve oils in order to be sure of smooth valve performance. One-pint containers, holding enough for an average engine, may be purchased at automotive supply stores. The instructions on the container usually recommend that on overhead valve jobs the oil be squirted directly onto the valve stems while the engine is running, and frequently suggest that some oil be introduced through the air intake of the carburetor (air-cleaner removed) while the engine is running.

There is basically no difference in the job on the hydraulic valve lifter in a straight engine (whether six or eight cylinder) and the job performed in a V-8. The thing to understand is that an engine warms up at varying rates and consequently is subject to varying degrees of expansion when going into service. This varying expansion upsets valve clearances in any engine utilizing solid valve lifters. Picture what happens

when the engine first starts up. Combustion at extremely high temperature is present in each cylinder and on each piston so the engine begins to warm up through the cylinder block. The first heating up takes place near the top of the block. As the heat progresses down the cylinder walls and up into the cylinder head, expansion actually lifts the whole valve rocker assembly, since this is mounted on the head. This increases clearances in the valve train to the extent of a few thousandths of an inch. With hydraulic valve lifters, the clearance is taken up and valve action remains unchanged. With solid lifters, the lifter has to travel a little farther to take up the clearance that has developed before it can open the valve. This influences valve timing slightly and has adverse effect on engine power. True, the difference is small; no driver would notice this. But engineers who are trying to corral the very last horse in their favorite engine consider these fine points. Naturally, this valve action goes on at one-half engine speed.

To clear up that point, let's review the engine operation. This begins with the intake stroke in which the intake valve is opened and the piston is going down into the cylinder bore. This fills the cylinder with a combustible mixture. Somewhere near the bottom the intake valve closes. The exhaust valve is already closed. So the piston goes up to top dead center, compressing the charge. Near top dead center the spark occurs and, with both valves still closed, the piston goes down on the power stroke. Near the bottom of the stroke, the exhaust valve opens and remains open while the piston goes up on the exhaust stroke.

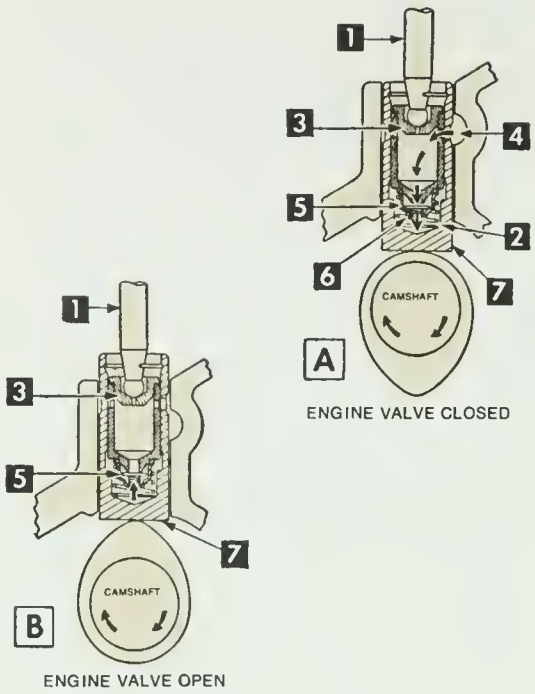
So we see that there is a complete cycle of valve movements at every other revolution of the engine. This fact can help in identifying tapping sounds. For example, if a tapping sound is present in the engine at what appears to be about engine speed, then the piston pins, rings, or connecting rods are more likely to be to blame than the valves. But, if the sound occurs at what appears to be about *half* engine speed, there is good reason to believe that the fault lies in the valve action somewhere.

To check for valve lifter noise you can either listen or feel, or use both methods as a double check. The first step in either case is to remove the rocker cover. Be careful of the gasket: it can often be used again. With the valve cover of an in-line engine or the two covers of a V-type or pancake engine removed, start the engine and let it idle (about 400-500 rpm). To listen to the sound of individual valves and their lifters, hold one end of a foot of garden hose firmly to your ear and hold the other end close to one valve at a time. Some noise will be picked up from each valve. But if you come to one that sounds like a lonesome woodpecker on a drainpipe, you have located your trouble.

To *feel* the valve action, place one or two fingers on the top of one valve spring retainer at a time, while the engine runs slowly. If the valve lifter is not performing as it should, there will be a distinct stinging or snapping effect on your finger. In other words the hammering that you hear will be the hammering that you feel. Now let's see what causes this annoying and power-destroying action.

If you experience a hard rapping noise contrasted with a moderate rapping noise, it is likely that the plunger is sticking in the bore of the lifter body. This means that the return spring within the valve lifter is unable to push the plunger into the working position to take up play or looseness (see sketch). This trouble is generally due to gum or varnish deposits from the oil used or to carbon formation.

There is also the possibility that the metal itself has galled. This galling, or picking up of metal, is commonly the result of the presence of abrasive dirt that was not



With engine valve closed there is no pressure on the push rod (1 in Fig. A), so the plunger spring (2) pushes up the plunger (3). Oil from the engine's lubrication system enters at (4), passes through the lifter valve (5) into space (6) below the plunger into the lifter body (7).

When the cam has turned to open a valve as in Fig. B, lifter valve (5) closes making the body (7) and plunger (3) a solid hydraulic ram. Thus the hydraulic lifter acts like a solid unit forcing up the push rod and opening the engine valve.

The automatic takeup of clearance *in the valve train is handled by the relatively light plunger spring (2 in Fig. A) moving up the plunger as any play develops. The oil then holds the plunger up.*

Continuous pressure on the plunger, however, will force the plunger down due to slight intentional leakage *between the plunger and the body. This continuous pressure is present on one or two valves when a car is left standing. This is why hydraulic lifters may be noisy for just a second or two when the engine is first started after having been idle for a period. Understanding that a* light *plunger spring takes up noise-producing clearance explains why even a little gum within the lifter body, or foreign matter between the plunger and the body, will cause noise. The plunger spring simply isn't strong enough to take up the clearance that develops in the system as the engine expands and contracts with changes in temperature.*

filtered out of the engine oil. The best preventive is the use of heavy-duty or high-detergent oil and the frequent replacement of the oil and filter—at least every 4,000 miles on a car using hydraulic valve lifters.

A moderate rapping noise heard during the garden hose check indicates considerable wear within the valve lifter or in the rest of the valve train, such as the valve stem tip and the rocker. All Chevrolets and most Fords have a moderate range of adjustment provided in the rocker arm retaining nut, to compensate for valve train wear.

To adjust, simply warm up the engine and run it at slow idle. (Turn back the idle speed screw until the engine will just lope along without stalling.) This will minimize oil squirting through the pushrods (which are hollow) all over the engine and you. If the oil squirting is unbearable, you can use large paper clips over the ends of the rockers, with one end of the paper clip stuck into the hole in the rocker, through which it is lubricated by the pushrod.

With a socket wrench, back off the rocker nut (counterclockwise) until the lifter begins to chatter. Then turn the nut clockwise until the chatter is just eliminated, and then one full turn more to position the lifter plunger properly.

Sometimes excessively fast lifter leakdown can be confused with wear in the valve train. To check, insert the thickest feeler gauge that will fit between rocker and valve stem tip.

If the problem is wear in the valve train, the lifter will not make any more noise as long as the feeler is in place. If the problem is excessive leakdown (a bad check valve or worn plunger), the noise will return in seconds.

If you find it hard to determine which valve is the noisiest since the whole system is annoyingly loud, check the quantity and quality of the oil in the engine. Frequent short runs in cold weather, exces-

sive use of the choke, or cold running will contribute to crankcase dilution. And this dilution of the crankcase oil will allow a rate of leakdown that will let the lifters become noisy. The first step in this case is to drain the oil while the oil is thoroughly hot and put in oil of the correct grade as specified by the engine manufacturer for the particular time of year.

If the valve lifter noise is the type that comes and goes, it may be caused by a very small piece of dirt which prevents the check-valve in the lifter from sealing tight. There is, of course, the possibility that the valve itself may have a small defect on it. And as the valve shifts around, this defect may occasionally interfere with action and cause the valve lifter to be noisy. At other times, the defect does not interfere and the valve lifter is quiet.

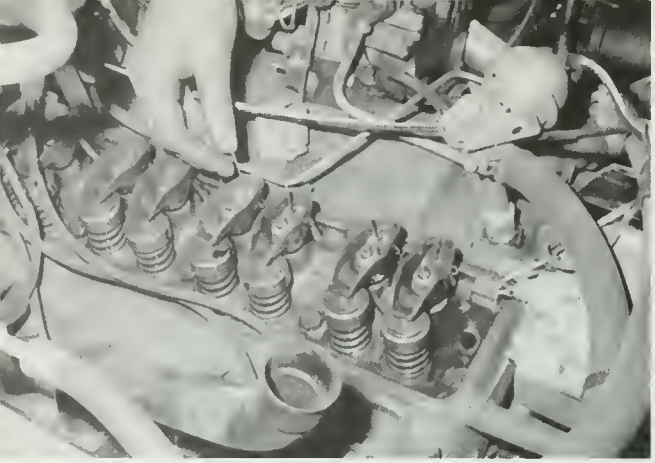
Before undertaking expensive mechanical work, try a commercial gum-dissolving solvent or special oil that will clean up any varnish or gum deposit in the hydraulic valve lifters. The methods of using the hydraulic valve lifter oil vary all the way from a normal oil change to a highly specialized lubrication system serving.

For example, one additive maker specfies that the engine should be drained, the oil filter cartridge removed, and the engine then refilled with a quart of SAE low oil plus 4 quarts of kerosene to which his product has been added. Then, due to the cleansing effect of this mixture, the engine must be run at what would give 15 to 20 mph for two hours, *outside* of the shop or garage. Then it is drained, the oil filter replaced, and the regular oil for the particular engine put in. Usually this clears up the entire valve lifter problem. Where the valve lifter noise has continued for so long that mechanical damage has occured or where the noise was due originally to wear or damage to the parts, then, of course, the use of a special solvent will accomplish nothing. This brings us to the job of removing, cleaning, inspecting reassembling and installing the lifters.

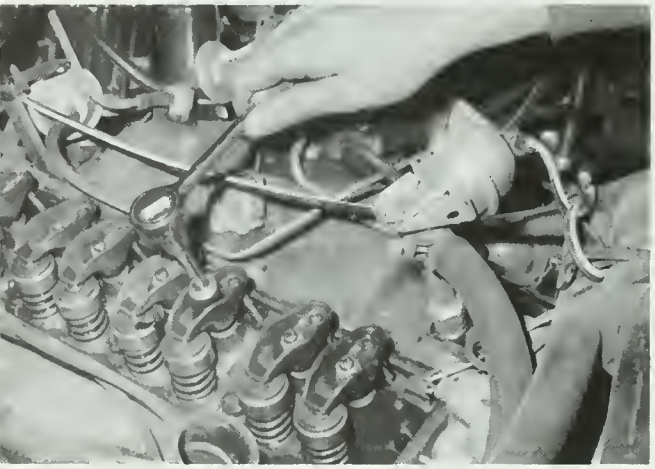
First, you will have to remove the one rocker cover on an in-line engine or two covers on a V-8. On an in-line engine, the side plate over the push rods will also have to be removed. In a V-type engine the intake manifold will have to be taken off. Then, on all types of push rod engines with rocker shafts, the valve rocker arm assembly must be either loosened sufficiently to release the push rods or removed entirely, if necessary, to get them out.

Now use the starter to turn the engine over at least two revolutions. This will push all of the hydraulic valve lifters up as high as they go in normal operation. If they fall down again, it merely indicates that they are fairly free in their guides. Sometimes carbon or gum in the valve lifter guide *above* the normal travel of the lifter will interfere with lifter removal, requiring a strong hook in order to get the lifter up. (Note: special tools are available for "impossibly stuck" lifters.) The lifters have one or two holes near the top to facilitate removal. To make a hook for one with two holes, straighten out a 20-inch length of heavy wire coat hanger and bend over exactly in the middle. Then bend the two free ends out with a ⅛-inch base for each "L" shape. Spread the wire sufficiently so that it will tend to spring out in the top of the valve lifter and grip the holes.

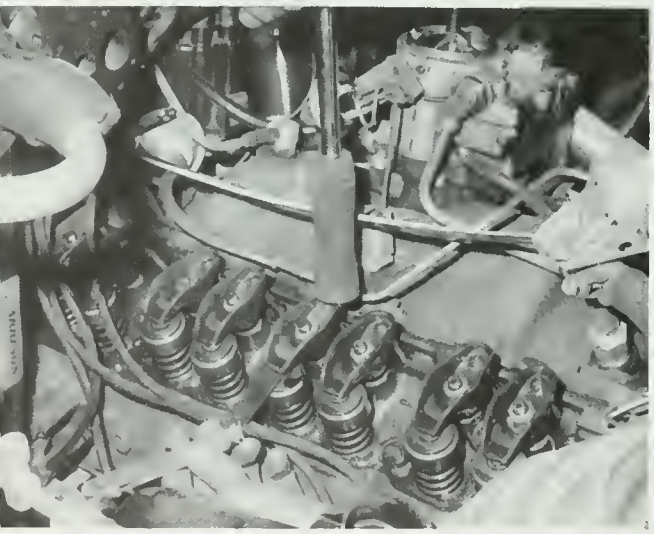
Place each valve lifter in the cup of a muffin tin. Use one muffin tin to represent the left block, another for the right block, and number the individual compartments from front to back so that each lifter can be returned to its original engine position. Soak each lifter in a commercial gum and varnish solvent; then, for complete cleaning, disassemble each lifter and return parts to the solvent. Keep the parts of each lifter together in the properly numbered compartment of the muffin tin. Plungers and lifter bodies are a selective fit when manu-



To prevent oil squirt as you adjust hydraulic lifters, use large paper clips around rocker, with tip inserted in hole in end of rocker as shown.



With engine idling, back off rocker nut until valve just starts to clatter, then turn clockwise to just eliminate clatter and a specified amount more (usually one turn, but check car maker's specs).



If you have a question about lifter wear, crank engine until valves for a cylinder are closed (piston up on compression stroke). Push on back of rocker to force oil out of lifter. Check valve clearance with feeler gauge and compare with manufacturer's specifications.

factured, and as they wear it becomes increasingly important that the same parts continue to work together.

Disassemble lifter by pressing the plunger down with one of the push rods from the engine and lift out the lockring. If, with the lockring out, hydraulic lifter assembly cannot be shaken apart due to gum on the plunger or inner core of the body, let it soak for a half-hour. Then strike the assembly lightly against a piece of soft wood, holding it in the right hand with the opening facing down. The inertia of the plunger will carry it out of the bore. Occasionally brush the parts soaking in the solvent with a one inch varnish brush to speed up the cleaning action. Then lift out the assemblies one by one and shake them dry. Compressed air may be used, but do not wipe parts with a cloth as the lint can cause trouble. Inspect each part for damage such as scratching or galling. Then try the plunger in the lifter body. It should move in and out freely of its own weight but should not have any noticeable looseness or side play.

Reassembly is easiest when done with all parts upside down. That is, place the push rod seat on the bench and put the plunger in position on top of the seat. Then put the check valve with its retainer on top of the plunger and the plunger spring on top of the retainer. Pour about a spoonful of engine oil over this plunger assembly, then slide the valve lifter body down over it. Holding the assembly in place in the body with the tip of one finger, turn the lifter right side up. Then, using a push

rod to force the plunger down into the body, put the lockring into position in the body groove.

Now replace all parts in the order in which they were removed. Be sure that the lockring snaps into the groove in the locking spring lifter body. When the lifter is assembled, you may be able to hear the check valve rattle when the assembly is shaken.

Now submerge the lifter in a clean container of SAE 10 engine oil. Pump the plunger up and down so that the lifter becomes filled with oil, then press down firmly on the plunger. If the plunger can be pushed down into the lifter body, it indicates excessive leakage between the lifter and the body or through the valve. Discard such lifters and substitute new ones purchased from your car dealer or automotive supply house. Test these as previously described before installing.

Now you can reassemble the engine. Remember, there is a limit to the takeup of a hydraulic lifter. For this reason, on engines that provide no mechanical adjustment in the rocker arms, each lifter should be collapsed after it is installed by applying continuous pressure on the push rod. When the lifter is collapsed by having forced out all the oil there should be .030 to .070 inch of clearance between the rocker arm and the valve stem. In checking this, crank the engine until the piston of the cylinder in which the valves are being checked is at top dead center of the compression stroke. On many engines it is possible to see the camshaft. On these it is only necessary to have the valve lifter on the "heel" of the cam—the lifter's lowest position—when checking the clearance. Obviously there can be no clearance when the cam is turned to open the valve. And it is very important that the cam is not in some mid-position which eliminates *some* of the clearance though the valve has not yet opened.

Another easy way to check for top dead center position of the piston is to use the distributor rotor. The rotor points to the distributor cap terminal of the piston that is at top dead center of the compression stroke. Should the clearance when checked prove to be less than .030 inch—which is most unlikely—it will be necessary to grind the end of the valve stem to give the required clearance. If the clearance is greater than .070 inch, replacement of the worn parts will be necessary. This could involve rebushing the rocker arm, renewing the rocker arm shaft or installing a new valve. Note: Most engines with hydraulic lifters have independently mounted rockers—no rocker shafts. No one can tell which will be required until the job is inspected. Occasionally, where no adjustment is provided, mechanics have improvised by shimming up or filing off the brackets that support the rocker arm shaft. A .004 inch shim between the base of the rocker arm support bracket and the cylinder head will increase valve clearance about .008 inch.

Since checking the hydraulic lifters in the block required compressing them and thus discharging all oil, they will be a little noisy until the engine oil has worked into them again. With the lifters in place, the push rods replaced and the rocker arm assemblies tightened down, start up the engine and let it idle. With the rocker arm covers still off, make a recheck of operations by listening at each valve for unusual noise, then feeling each valve spring as the engine idles. There should be no stinging shock on your fingertip. If you have followed the foregoing procedure step-by-step you have saved at least $50, and you have the plus-satistfaction that comes from realizing that hydraulic tappets don't have to be noisy—that they can, in fact, give you a bonus of silence and power when properly used and serviced. P.W.

See also: REPAIRS, AUTOMOBILE; PARTS REPLACEMENT, ENGINE; VALVES.

Engine cleaning can be done with an aerosol degreaser. Air cleaner should be removed and carburetor opening covered with plastic wrap. Distributor should also be plastic-wrapped.

Taking Care of Your Engine

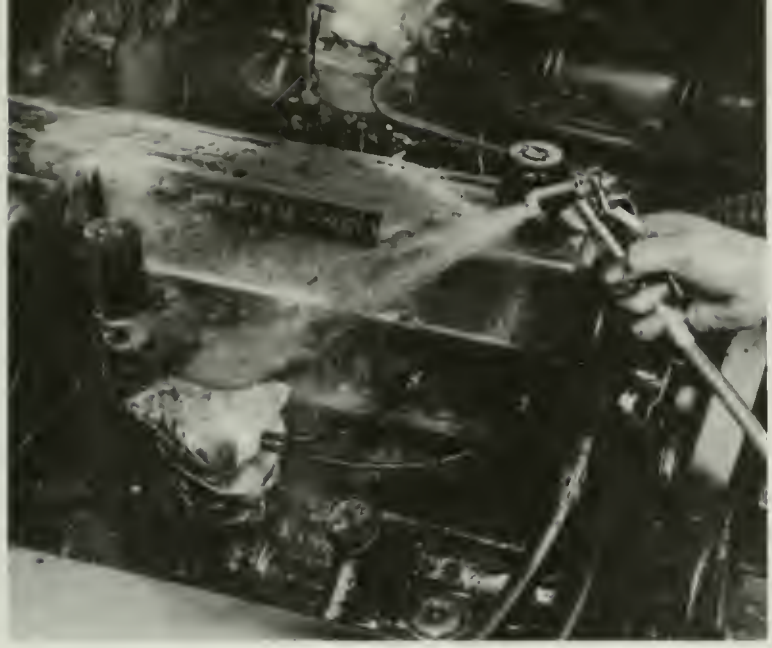
A little attention at the right time can head off trouble, save repair costs and add miles to the life of your car

YOUR CAR'S DRIVING power starts with its engine, and just as long as cars continue to utilize internal combustion engines, engines will continue to receive the greater share of car maintenance. This is so because the engine, in addition to its own mechanical structure—block, head, oil pan, oil pump, crankshaft, pistons, rods, bearings, flywheel and timing gears—takes in the all-important ignition, carburetion, and cooling systems. And on today's smog- controlled cars, there is even more, such as Positive Crankcase Ventilation and special ignition timing controls.

If each of these individual units is kept up to standard, your engine will perform substantially as it did when new, even after thousands of miles of operation. But car owners usually become somewhat careless; when the thrill of new-car ownership has worn off, they tend to take their car and its engine for granted. Only when trouble shows up do they realize that a little attention at the right time would have forestalled trouble, saved them repair costs and —as a plus factor—made their car last much longer.

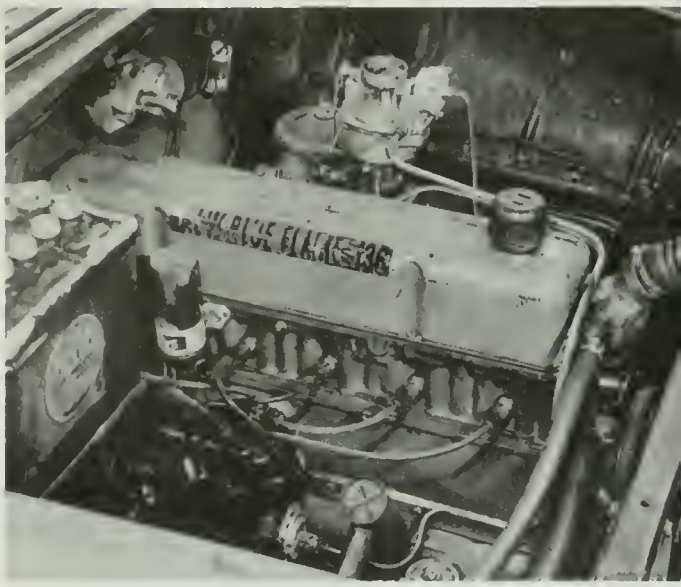
When you get your new car, every unit in it is brand new, and moving parts fit with just the right clearance. Then, in time, the engine parts gradually become worn so that clearances between rubbing metal enlarge, components in the ignition system become so worn that timing is late, spark plugs wear out and erosion of the plug electrodes widens the gaps so that plug performance falls off. Other parts loosen or disconnect. Dirt and other foreign matter impedes the operation of the fuel, lubrication and cooling systems, the power and zip of the engine falls off: in short, the engine ceases to purr. . . . Periodic attention could have prevented all of this.

Keep your engine clean. It doesn't take a "mechanically minded" person to keep the outside of the engine clean. And keeping the outside of the engine clean is the



After solvent has had a chance to work, spray it off with a garden hose.

This is the same engine as in the first illustration. The car is old, but the engine doesn't show it.



Jacking capability is needed for underbody work. Among the less expensive jacks available for weekend mechanics is this "trolley jack," which has three wheels for easy positioning and jacking.

Once car is raised, safety stands should be placed under lower A-frames. You don't need expensive ones. The 5000-pound capacity stands illustrated are inexpensive.

first step toward getting the longest possible life from your engine.

Excess operating heat from your engine is dissipated by being passed to the atmosphere through the radiator core, the engine oil pan, and to some extent through other surfaces such as block, cylinder head, and manifold. If you keep the outside of your engine clean, its operating temperature will have a better chance of remaining normal at all times. A dirt-caked oil pan, on the other hand, will not permit excess heat to escape and the bearings, crankshaft, pistons, rods and other parts will operate at higher than normal temperatures. The oil itself may overheat, oxidize, become black and lose much of its lubricating value.

Dirt and road film can also cause carburetor linkage to stick, mask an oil leak while it is still easy to cure, enter the brake master cylinder and contaminate brake fluid, and create electrical short circuits.

If you clean your engine just once a year, or twice a year in areas where winters are severe, you can greatly extend the life of many components.

You don't need an expensive steam-cleaning system to do the job correctly. For a few dollars you can buy an aerosol can of engine-cleaning solvent, and it will do an equally good job.

Just remove the air cleaner assembly and with clear cellophane household wrap, cover the generator end plate, top of the carburetor and the distributor body. (These must be cleaned separately with kerosene and a wire brush to keep dirt and water from entering these units.)

When making compression test, make sure all plugs are out, engine is warm and throttle is blocked open. Watch action of compression gauge needle for indication of condition of valves.

Fuel pump capacity test is made by cranking engine with fuel line end disconnected from carburetor and aimed into can. Pump should deliver a pint in 30 seconds on V-8, 45 seconds on a six.

Spray the engine with the degreasing solvent, using a repeat spray on areas with caked-on film. If the cake of dirt is really thick, you may have to scrape it off. The solvent works best when the engine is warm.

Allow the solvent to work in for about fifteen minutes, then wash it off with a garden hose.

A clean engine has the additional advantage, to a weekend mechanic, of being much easier to work on. Adjustment screws are easier to regulate when they are clean, and nuts and bolts can be tightened properly only when clean. (Dirt causes thread friction that gives a false sense of tightness.)

Keeping the engine clean means keeping *all* of it clean. In addition to brush-and-solvent cleaning of the generator, top of carburetor and distributor, also brush out well around the spark plugs, so that when they are taken out, no foreign matter will fall into the plug hole. Such dirt could lodge under a valve seat to prevent its seating, and it would take a very short time for the valve and seat to burn, which would require an expensive and time-consuming repair.

Some other simple steps. Over the miles, engine performance falls off gradually—but few engines ever have to have all adjustments and tune-up work done at one time. If your engine seems to be ailing, look first for one of the relatively simple sources of troubles listed in the table, "Simple Engine Troubleshooting."

With the possible exception of bringing the ignition distributor up to standard specifications, you can, with no special equipment, easily make all of the adjustments and repairs listed in the table.

You will be helped considerably in your efforts to keep the engine at its best by buying a set of socket and open end wrenches. If you cannot get these at a hardware store, you can at an automotive parts and equipment jobber. With a set of such wrenches you can go over all the various nuts in the engine, tightening those at such parts as intake and exhaust manifolds, carburetor joints, valve cover plates, timing gear cover, oil filter brackets, fuel lines, oil lines, oil pan—in fact, wherever the nuts are accessible. Be careful of the nuts on the cylinder head. These should be tightened with a torque wrench (a wrench which shows the exact amount of tension being placed on the stud upon which the nut is being tightened).

Jacking capability. If you presently have your car lubricated and the oil filter changed at a service station, you may wish to have underbody bolts and nuts, particularly oil pan bolts, tightened by the station attendant while the car is on the lift.

But if you have a late-model "lubricated for life chassis" you should consider changing the oil and filter yourself. You can normally buy the oil and filter at discount houses and auto supply stores for less than the list price the service station charges.

Most cars have spin-on filters which require only an inexpensive wrench to replace. The oil pan drain plug requires only a simple box or open-end wrench. The elimination of the chassis lubrication means that you do not need to use an air-pressurized grease gun or struggle with a small hand grease gun.

You will, however, need good jacking capability to do this work. But you will need this for many routine underbody jobs, including underbody nut and bolt tightening, which you will then be able to do yourself.

Using a vacuum gauge. A vacuum gauge is a handy and inexpensive instrument that can tell you much about engine condition. When an engine is performing properly, the downward stroke of the pistons creates a healthy vacuum in the intake manifold. Engine malfunction often shows up as

changes in intake manifold vacuum, which you can measure with the vacuum gauge.

The vacuum gauge is easily connected to either the base of the carburetor or to the intake manifold itself. (The intake manifold is the tubular unit that sits below the carburetor. It carries the fuel mixture into the cylinder head.)

Testing compression. Good operation of your engine depends to a great extent upon having uniform compression in all the cylinders. A compression gauge tests for this. Before removing spark plugs from all cylinders to make such a test, the engine should be operated long enough to bring it to its normal operating temperature. Next, loosen all plugs two turns to crack internal carbon, then start and "gun" engine to blow out this carbon. Now you can remove the spark plugs, open the carburetor throttle valve wide and block the accelerator pedal if necessary to hold it in this position. Also make sure that the carburetor choke valve is wide open. Place the compression gauge in the plug hole of the first cylinder (hold it firmly in place), and with ignition disconnected (pull center wire from coil) have someone crank the engine. Watch the pointer of the compression gauge and count the number of revolutions necessary to bring the hand to its highest indication. Actually, you do not count the engine revolutions, but rather the *whrr whrr* of the starting motor. Jot down the reading and do the same with the remaining cylinders.

If you have the correct grade and amount of oil in the engine and if pistons, rings, cylinders, valves and gaskets are in good condition, the highest readings on all cylinders should be within 25 percent of the lowest readings. If there is a greater variation, there is an engine mechanical problem, and normal tuning will have very limited effect. Example: if the highest compression reading is 160 psi, the lowest should be 120.

The important thing to watch for in this test is the action of the compression gauge pointer. For example, if the pointer does not climb steadily, but remains at rest during the cranking process, indications are that the valve of the cylinder on test is holding open. Or, if on the first turn of the starting motor the hand goes to 35, for example, then remains at 35 on the next turn but climbs higher on succeeding strokes, it is likely that the cylinder has a sticky valve. Such a valve condition will show up on the first few revolutions during the test.

Note: On many V-8 engines, it will be impossible to hold the compression gauge in the spark plug hole as required, and still be able to read it as the pointer rises. If you have a V-8 and this is the case, you will need a compression gauge with a hose. One end of the hose has a threaded fitting for the spark plug hole. The other end has the gauge, which can be held away from the plug hole and read easily.

Head gaskets leakage is generally indicated by low compression readings on adjacent cylinders. If the readings you have jotted down show definite lack of uniformity between cylinders, you can often restore normal conditions by using a special gum solvent or similar preparation sold by auto supply stores for this purpose. Valves and piston rings freed in this way may again seat firmly to restore compression; but if the valves are burnt, the obvious remedy is replacement of the old valves with new.

The cooling system dissipates the excess heat from the engine. It must always be kept in the best of condition. At one time it was necessary to drain the system twice a year—once in the spring, again in the fall.

But today's cooling systems are designed differently. They require only once-a-year draining, and year-round use of antifreeze.

The fuel pump draws gasoline from the tank and forces it up into the carburetor,

usually through a gasoline filter. It is a simple unit that normally functions for up to 50,000 miles or more without giving trouble.

The pump has two valves, both spring-loaded but in different directions, and a diaphragm that is connected to an arm. The engine camshaft has a lobe that moves the arm to flex the diaphragm.

As the diaphragm flexes downward, it creates a suction that pulls open one of the two valves, called the inlet. The suction also draws in fuel from the gas tank.

As the camshaft turns, it relieves the pressure against the arm, and a spring pushes the diaphragm up. The spring pressure against the diaphragm forces the fuel against the other valve—the outlet—opening it and pushing the fuel out of the pump and up the tubing to the carburetor.

Eventually, however, the diaphragm may become punctured by dirt in the gasoline, or porous, and insufficient fuel will be pumped to the carburetor. And over a period of time, the diaphragm arm may become excessively worn.

Fuel pumps can be tested with a pressure gauge that reads to about nine psi. All vacuum gauges sold for engine troubleshooting also have a pressure gauge built in, so you need not purchase an additional test instrument.

The pressure gauge is normally connected to the end of the fuel line at the carburetor. The engine is cranked, or even started (and operated for a moment on the fuel in the carburetor), while the pump output pressure is read on the gauge.

The correct pressure varies according to the make of car. In general, a six-cylinder pump is satisfactory if it develops 2.5 to 4 psi. A V-8 pump normally develops 3 to as high as 8 psi. Inadequate pressure causes fuel starvation; too much pressure causes carburetor flooding.

In addition to a pressure check, a volume check should also be made. This is done by cranking the engine and holding a can to catch the flow from the fuel line, and is most conveniently performed immediately after the pressure check. A six-cylinder pump should deliver a pint into the can in 45 seconds at most. A V-8 pump should deliver a pint in 30 seconds.

If fuel pump delivery is not up to specifications, the problem may be caused by a clogged gasoline filter. On many cars, the fuel pump is a sealed assembly and must be replaced if defective; on others, it can be rebuilt.

The carburetor. Modern carburetors can be complicated units, particularly if they have two or four barrels. You can, however, do some carburetor service work yourself even with little experience.

Light carburetor service is limited to the following:

1. Adjusting the carburetor. You will need a tachometer for this. The tachometer, which is an engine speed indicator, is normally sold as a combination unit with a dwellmeter, which is needed for checking ignition point adjustment.

Inexpensive tach-dwellmeters for weekend mechanics are sold by discount and auto accessory stores. You should not buy the least expensive, for these will be very difficult to read accurately. Unless the tachometer has scales at least 2½ inches wide, and the dwellmeter preferably about three inches, neither will be readable. The tachometer should have two scales for versatility: 0-1000 rpm and 0-5000 rpm. The better tach-dwellmeters (also called dwell-tachometers) have chrome metal cases and cost two to three times as much as the ones with small scales and plastic cases. You may be able to get units with plastic cases and readable scales for a price somewhere between the lowest and highest. These are a good choice; you do not need the durability and ruggedness of the chrome case.

Connect the tachometer as specfiied by

the instrument manufacturer (normally to the thin-wire "CB" or minus sign terminal on the coil, and to an electrical ground, such as a cylinder head bolt).

With the engine fully warmed up, you should adjust the idle mixture screw. This screw is near the base of the carburetor. Turn it clockwise until the engine starts to falter, then counterclockwise one turn.

Note: On late-model cars with emission controls, the idle mixture screw may have a plastic cap that limits how much it can be turned. Somewhere within this range of adjustment, the engine should idle smoothly. Otherwise, the plastic cap may require removal and the carburetor adjustment by a professional shop with an exhaust analyzer.

Once the mixture is set, you can adjust the idle speed. This is controlled by a screw against the throttle linkage, which you can identify by its return spring (or by stepping on the accelerator pedal and seeing what moves).

Turning the screw clockwise increases idle speed; turning it counterclockwise decreases it. On most automatic transmission cars, idle speed is set with the emergency brake applied and the transmission shift lever in "drive" position.

A satisfactory idle speed is normally about 500 rpm for a V-8, 600 rpm for a six-cylinder, although on a somewhat older engine, you may have to increase the speed 150 rpm to obtain a smooth idle.

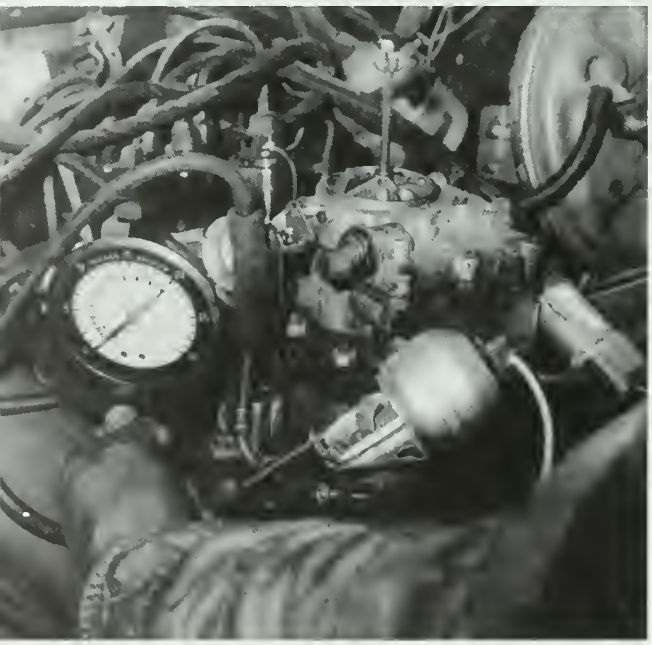
There is a limit to how high to set the idle speed on automatic-transmission-equipped cars. Most automatics will creep if the idle is too high, an inconvenience most motorists will not accept.

2. Checking the accelerator pump. Most carburetors have an accelerator pump, which squirts extra fuel into the air horn when you floor the accelerator suddenly. The extra fuel prevents fuel starvation under hard acceleration, which could cause "flat spots." If your engine hesitates on hard acceleration, remove the air cleaner with the engine turned off, and have someone pump the gas pedal while you peer into the carburetor air horn. With the pedal being pumped, there should be squirts of fuel into the air horn.

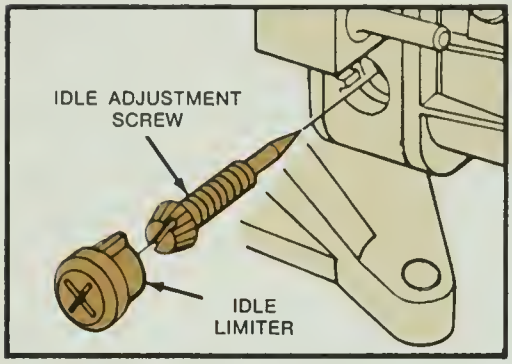
If there are none, the carburetor requires disassembly and replacement of the accelerator pump. If the squirts are very weak, perhaps the problem is that the pump arm is not connected to the correct hole of the external linkage. For maximum pump stroke, the pump linkage (which you can identify by watching what moves on top of the carburetor) should be connected to the top hole if there are more than one. To change the rod adjustment, take off the retaining clip, move the rod to the top hole and refit the clip.

The pump must have its longest stroke in winter, its shortest stroke in summer.

Fuel pump pressure test is made with fuel line end disconnected from carb and vacuum-pressure gauge attached. Check manufacturer's specifications which will tell you what pump output should be.



Adjustment of carburetor idle mixture on late model cars is restricted by plastic idle limiter. However, you should be able to get an acceptable idle within its range.



Drawing shows that limiter is nothing more than a plastic cap over the conventional idle mixture adjustment screw.

3. On some older Holley-brand carburetors, you can also check the fuel level in the carburetor bowl. If you see a plug threaded into the side of the bowl, remove it with the engine running; fuel should just dribble out. If no fuel comes out, or if the fuel really pours out, the fuel level is too high and the top of the carburetor must come off.

Thermostatic controls. Modern engines use either of two means (and occasionally both) to warm up the incoming air mixture for better fuel vaporization (and better combustion) when the engine is cold.

The most popular system over the years is the manifold heat control valve, also called a "heat riser."

On late model cars, a "thermostatic air cleaner" is used. This is nothing more than a valve in the air cleaner snorkel and a duct over the exhaust manifold. A thermostatic control ducts air warmed by the exhaust manifold into the engine during cold operation. As the engine warms up, the valve pivots to close off the exhaust manifold duct and open the snorkel to intake air flow.

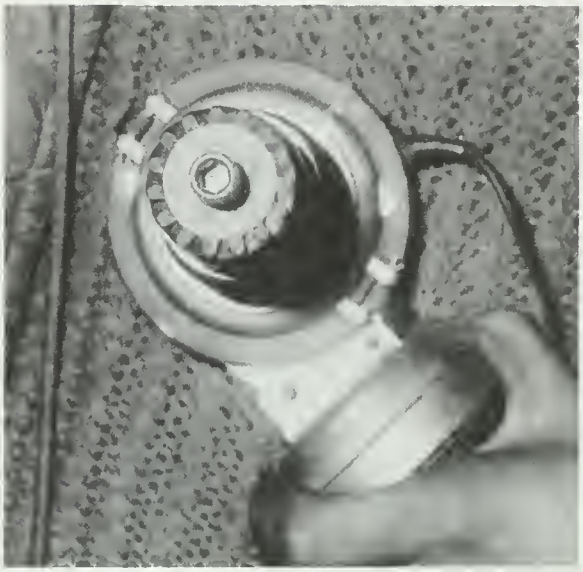
Valve adjustment. The valves in your engine may be adjustable, even if the valve lifters are the "hydraulic" type. In addition, all valves with mechanical lifters are adjustable.

Most foreign cars, most six-cylinders and most Ford and Chevrolet V-8s have adjustable valves, whether hydraulic or mechanical. Valve adjustments are well within the ability of the weekend mechanic.

Valves should be adjusted at least once a year. Wear in the valve train creates the need, and periodic adjustment makes certain the valves open and close at exactly the right times for good engine performance.

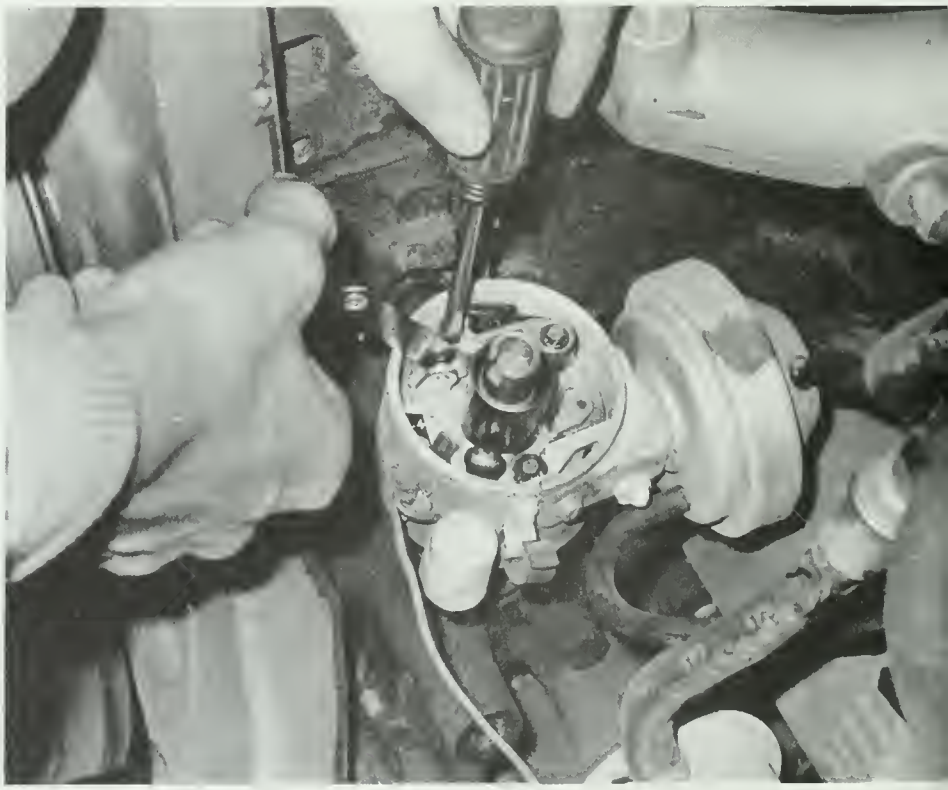
The ignition system. Periodic checking and replacement of the spark plugs will not only prolong engine life, but will help

you to get maximum fuel mileage. Spark plugs when correctly chosen for the engine operate for a long period, but eventually lead in gas, oil and combustion heat cause gradual loss of efficiency. The insulators accumulate deposits and the result is that the spark electricity tracks along the insulator up inside the plug rather than across the intended gap. The electrodes, too, become eaten away so that the gap becomes wider than the normal setting called for.



In adjusting electrode gap, always bend the outer, never the center, electrode. Gaps vary from .022 to .040 inch, the average being about .035 inch. Spark plug makers and service stations have specifications listing all makes of cars and the correct gap setting for each model. When the plugs are installed, tighten them only enough to compress the gasket. When buying new plugs, be sure they are of the heat range specified for your engine. Plugs are classified hot or cold according to the exposed interior length of the insulator. A hot plug does

End view of Ford distributor shows the problem of installation. Note hexagonal hole in center and gear that must be engaged.



Normally, ignition points can be replaced and adjusted without removing distributor.

SIMPLE ENGINE TROUBLE-SHOOTING

Condition	Possible Cause	Remedy
Low gas mileage.	Dirty air cleaner.	Replace paper air filter. For other types, see section on filters.
Starter works too slow; lights almost go out when starting; engine does not start; lights brighten when engine speeds up.	Battery at low charge.	Have battery charged and tested for condition of cells.
Sluggish starting motor; engine starts hard, lights dim with engine not running.	Loose, corroded, frayed or broken battery cable or ground strap.	Clean and tighten terminals or replace old cable and ground strap with new ones.
Water dripping when car is at rest.	Leaking water hose connection, defective water pump or radiator cap.	Tighten hose clamps or replace hose with new one. Have professional shop check pump and cap.
Engine overheats; water in cooling system boils.	Loose or broken fan belt or defective radiator cap.	Adjust tension of belt or install a new belt. Have professional shop check cap.
Engine starts hard or fails to start; poor gasoline mileage.	Choke sticking partly closed.	Remove air cleaner and free choke valve or linkage with kerosene or aerosol solvent.
Slow acceleration when "stepping on gas."	Wrong seasonal setting of carburetor.	Make correct setting of seasonal adjustment for cold, hot or normal temperature.
Misfiring; rough operation; poor gasoline mileage; hard starting.	Worn out or wrong type of spark plugs.	Replace plugs with a new set of correct type and heat range.
Flooding carburetor.	Dirt or chip stuck under carburetor float valve.	Remove carburetor float bowl cover, remove float and float valve. Look for foreign matter on valve or its seat.
Rough engine operation; misfiring; hard starting.	Pitted or wrongly spaced distributor contact points.	Install new points if old are badly worn.
Low gasoline mileage; engine lacks power and pick-up.	Heat control valve sticking.	Squirt aerosol solvent on shaft and tap lightly with hammer until free.

not have a "hotter spark." Hot plugs burn off fouling deposits in low-speed driving. Cold plugs prevent insulator blistering from the heat generated in high-speed driving.

As far as the ignition distributor itself is concerned, it should not be removed from the car unless absolutely necessary, as for replacement. Ford distributors, for example, have a gear and a hexagonal slot on the shaft, and engaging both properly can be a very difficult job.

Most routine checks of the distributor can be made on the car, as can replacement of the ignition points and condenser.

Muffler and tail pipe. A badly corroded muffler, broken or disarranged baffle plates, together with a kinked pipe, may produce enough back pressure to offset all of your other good work. P.W.

See also: AIR CLEANERS; ANTI-POLLUTION; CARBURETORS; PARTS REPLACEMENT, ENGINE; VACUUM GAUGE; VALVES.

How to Maintain and Repair Small Engines

Care and simple repairs can make your small engine machines run economically and last years longer

TALK to an engine repairman and he will tell you that the typical 2, 5, 10, or even 12 horsepower engined snowmobile, lawn mower, mini-bike, snow blower, go-cart or out-board motor owner gets only about one trouble-free year for his investment. By the second year he's having trouble starting or trouble handling heavy loads. At the end of a bothersome year, many are willing to unload what they consider a lemon and buy a new one next season. But, with a little care, you can have better luck.

Gasoline selection is a good place to start. Regular is the proper choice, not high test and not white gasoline. Unless you have a two-cycle engine—such as on an outboard motor, most chain saws and a few lawn mowers—do not add oil to the gasoline. If a mixture of oil and gasoline is required, your user manual will tell you. Take note of the fact that more oil is mixed with gasoline during the break-in period than is normally required in two-cycle engines.

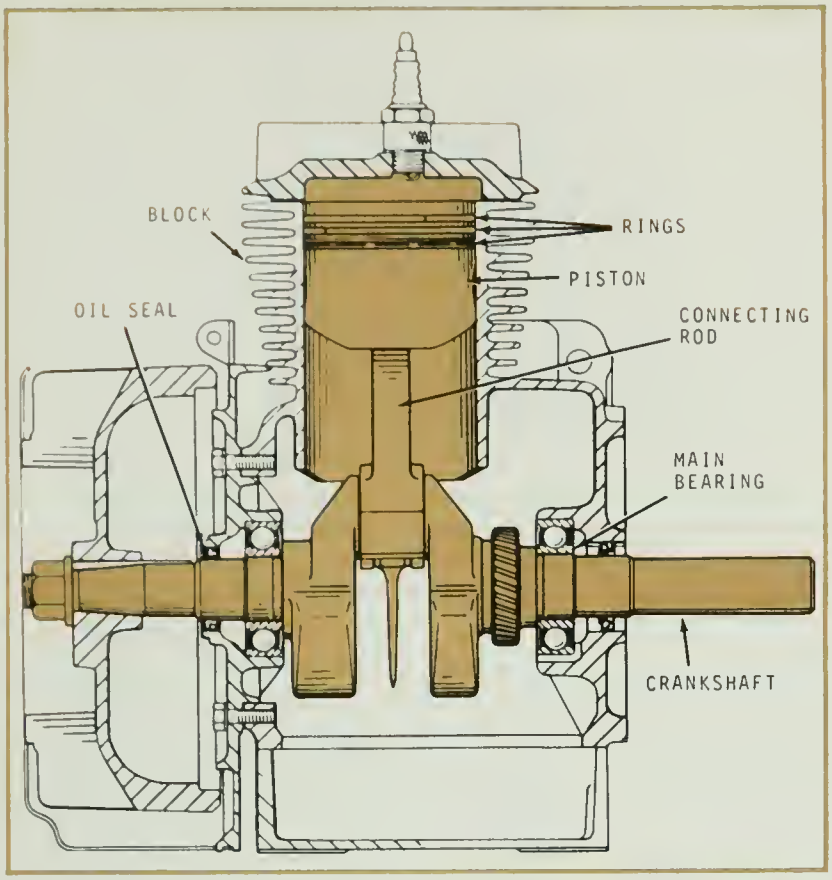
Lead is as harmful to your small engine's valves and piston rings as it is to your lungs. Try to buy either the lead-free or the low-lead fuels. Those lead-packed deposits around the valves and rings in your car can go just about unnoticed because you have half a dozen cylinders pulling the load. The small engine has only one set of valves so a chunk of leaded carbon on a valve seat can be a major calamity.

Gasoline companies change the blend of their gasoline according to the season. They add light, volatile chemicals in the winter to assist starting. And in the summer they put in additives to cut back on "boiling" and vapor locks. Take advantage of the best blend for the season by buying your winter sports gasoline in the winter and your lawn mowing gasoline in the summer.

Do not store gasoline very long. One year is the absolute maximum length of time you should keep a supply on hand because it oxidizes. A tank or can of gasoline exposed to even a little air gradually builds up deposits of varnish and gum, and you can imagine what that will do to carburetor openings, fuel pump diaphragms and valves.

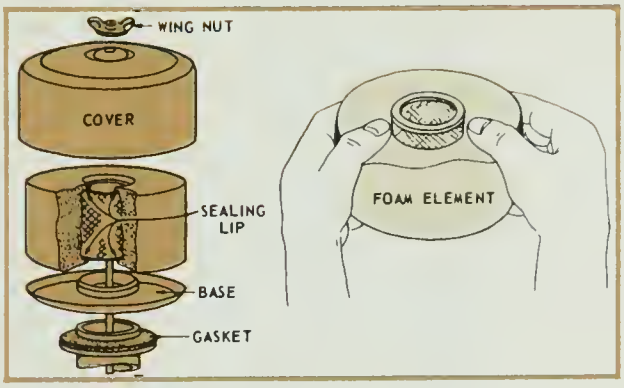
Oil comes in several different grades. Oil quality ratings are actually expressed in letter codes such as DM, DG, ML, MM and MS. The DG and DM are high detergent oils intended for diesel engines and will not do well in a small gasoline engine. ML is for light service in a gasoline engine and should also be avoided. MM is the minimum recommended grade for small gasoline engines. And MS, which is intended for severe operating conditions, is preferred. If you have an additional choice

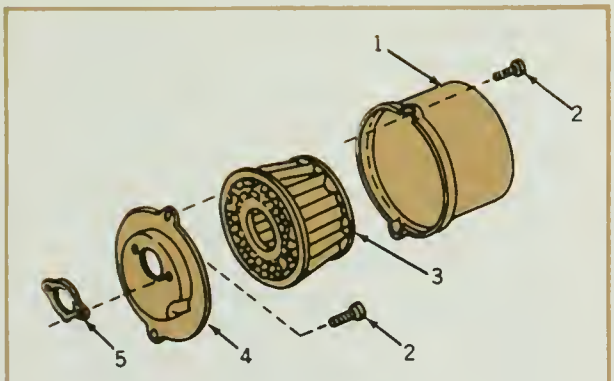
engine tune-up: see tune-up, engine
entertainment center: see furniture, indoor
epoxy: see adhesives
etagere: see plastics, fabricating
evergreens: see trees



Cutaway view of a typical 4-cycle engine. They are easy for the home mechanic to repair.

Oil foam air cleaner is cleaned by washing in water, wiping with clean cloth, adding enough clean motor oil to soak the foam, then squeezing out the excess.





Air Cleaner Components

1—Air Cleaner Body
2—Screw (4 used)
3—Air Cleaner Element
4—Air Cleaner Base
5—Gasket

Paper air cleaner elements can be cleaned by knocking on soft surface and brushing with a soft brush.

of detergent or non-detergent, pick the detergent. (Oil companies are in the process of changing over to new codes; under the new system, SC or SD are the grades to look for.)

Outboard motor oil, used for mixing with gasoline in two-cycle engines, is also rated by quality codes. The MM and MS (or SC and SD) grades are proper here.

The end of the season, unfortunately, is one of the most important times in the life of any gasoline engine. The rust, varnish, moisture and gunk which accumulates because of inactivity can be as damaging as rough and steady use of an engine. Drain the gas tank and fuel line thoroughly. Then add fresh gasoline and flush the tank, carburetor and fuel line again. Unless the carburetor and fuel lines are ideally suited to being drained, you will probably have to run the engine awhile to consume the last drop of fuel. A tank and carburetor left with gasoline in it over a winter or summer will be seriously hampered by deposits of gum and varnish—if not after the first year, then after two or three years.

Change the oil as part of your end-of-season ritual. And flush out the oil pan with thin oil before filling with fresh oil for the rest period. The moisture and acids which build up inside the oil and oil pan after a few hours of use can be doubly damaging when given six months of free access to metal parts. While you are changing the oil, apply some to all of the moving parts which benefit by oil. However, do not squirt grease into fittings at the end of a season. Left untouched for several months, grease gets very stiff. You will be much better off by adding fresh, unstiffened grease to fittings at the start of your next season.

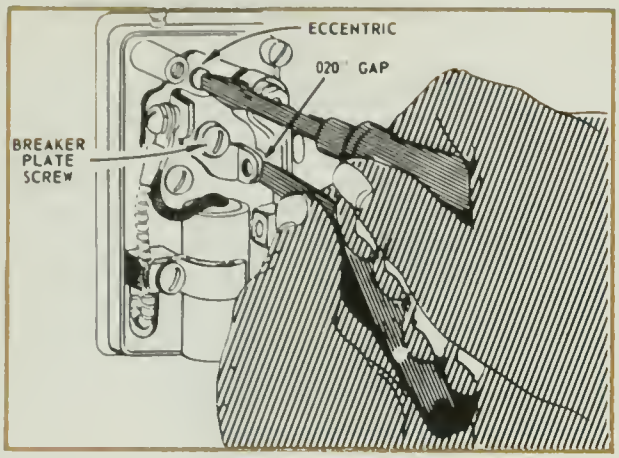
Also at the end of a season, remove the spark plug and add a tablespoon of your normal oil through the spark plug hole. Then move the piston up and down several times by spinning the flywheel or starter. This extra oil will smoke like the devil when you start the engine next season but, in the meantime, the oil will protect the cylinder, piston and piston rings from moisture.

Oil is helpful for all non-moving parts to prevent rust over a winter or summer of rest. An aerosol can of light oil makes for an easy oil treatment of all metal parts like lawn mower handles and blades, the inside of metal bodies and frames, chain saw blades, snow blower blades, plus miscellaneous chains and controls.

If you are leaving a storage battery in a cold garage or basement over the winter, make sure it is fully charged. A discharged storage battery can freeze and crack the cells wide open. The nickel-cadmium batteries are unaffected by cold temperatures but they cannot be charged when the thermometer rests below 40 degrees without serious damage.

Two of the simplest, yet most important, routine maintenance requirements are ignored by many people pushing equipment with small engines. Change the oil. In dusty parts of the country, or during dry spells, change the oil every week or every month if your engine gets much use such as on go-carts and scooters. Unless you put them to professional use, you should change the oil in mid-season, at the end of a season and at the start of every season on lawn mowers and snow blowers. Pros must change the oil weekly.

Clean the air cleaner. It is believed that only one out of every thousand lawn mower owners bothers to even check the air cleaner, a fact which results in the typical rotary power mower lasting only two years when it should last for five. Shortened life span hits every engine with a neglected air cleaner. Air cleaners are especially vital on those appliances which get into more dust than the rest—chain saws, roto-tillers and rotary lawn mowers. Many engines on snowmobiles do not have an air cleaner;



Correct gapping of plugs and points is important. Points are almost universally set at .020-inch.

as a result they should not be adapted to any summer-time pleasures. The user manual should give detailed instructions on how to clean the particular air cleaner included with your engine.

Air is one of two vital ingredients for every gasoline engine. If it weren't for an effective air cleaner, the pistons and valves would soon be scratched by sand and dust and bird feathers. If you have any doubt about how well yours is functioning, replace it.

Oil helps small gasoline engines keep their cool. But air does the rest. Consequently, the cooling fins on your engine have to be kept clean. Some go-cart and scooter owners happily bolt on shroulds, cowlings, decorations, windbreakers, fenders and bodies, forgetting all the while that if a steady stream of cool air is not available for the engine, it's going to run hot, which means it will run for fewer years. Some outboard motors are air cooled and the cooling fins on those models have to be kept free of seaweed, fish scales and other nautical debris. Wood chips and saw dust plague the chain saw cooling fins; grass and leaves clog the fins on lawn equipment. Fortunately snow isn't much of a problem on the well heated cooling fins of snowmobiles.

Engines which run for long stretches at high speeds build up a lot of carbon which becomes especially harmful around the valves first. Four cycle engines given heavy use, such as professional lawn mowers and garden plows, or rental and resort-based go-carts, scooters and snowmobiles, should have carbon removed from the valves and cylinders about once a month. This means, of course, that you'll have to pull off the cylinder head which is only a five minute job on tiny gasoline engines. Engines used only occasionally should have the carbon cleaned off the valves and pistons every year or two. Either learn to do it yourself or take it to a competent repair shop.

Two-cycle engines, the type common on outboards, chainsaws and even some lawn mowers now, have no metal valves. Instead the usual maintenance procedure calls for removing the muffler and using a wooden dowel to gently ream away carbon which has accumulated at the open exhaust port.

One of the best investments you can make when you buy a fun-mobile or a draggy lawn mower, is the official repair manual put out by the engine manufacturer. You may not be equipped to handle *all* of the repairs covered by the manuals, but the maintenance tips and minor repair instructions you will pick up are worth the investment. F.P.

Easy-to-build Jogging Machine

With this exerciser you can jog indoors in the privacy of your home at a cost far less than for one ready-made

TO MAKE THE JOGGER effective, a wide belt of plasticized cloth is fitted over a series of closely-spaced rollers that are on a slope. With this arrangement, there is plenty of support for your feet as the treadmill turns.

Side, front, and rear panels are cut from hardwood stock. You can make up full-size patterns as cutting guides.

Lay out the bearing hole locations on the inside face of each side piece. Drill the ½-inch bearing holes each ½-inch deep. You can place a mark on your drill bit so the holes will be uniform in depth. The first hole—the one nearest the front panel—is ⅞-inch in diameter and ⅜-inch deep.

Insert ⅞-inch O.D., ⅜-inch I.D. ball bearings in the two front holes, and ⅜-inch nylon bearings in the remaining holes. The narrow end of the bearings go in first. Tap them gently with a hammer to set them level with the surface of the wood.

To make the elongated socket for the rear tension roller assemblies, drill two 1⅜-inch holes $1\frac{3}{16}$-inch apart, and ⅜-inch deep. Clean out the points between them with a chisel to form an oval hole. The slot for the threaded section of the eyebolt can be cut with a saw, then cleaned out with a chisel.

The rear tension assembly for each side is an eyebolt with a ball bearing tapped into the eye. It should move freely in its socket.

Make up a jig for drilling pilot holes in the ends of rollers. Use a 1⅝-inch x 2⅝-inch x 2⅝-inch block of hardwood. Drill a ⅛-inch hole through its center and a 1⅜-inch hole 1-inch deep.

Prepare the rollers by cutting 1⅜-inch diameter closet poles into 14¾-inch lengths; 20 are needed. Slip the pilot hole jig over one end of each roller, and drill a $\frac{3}{32}$-inch hole ½-inch deep in the roller. Repeat at the opposite end. Steel pins (pop

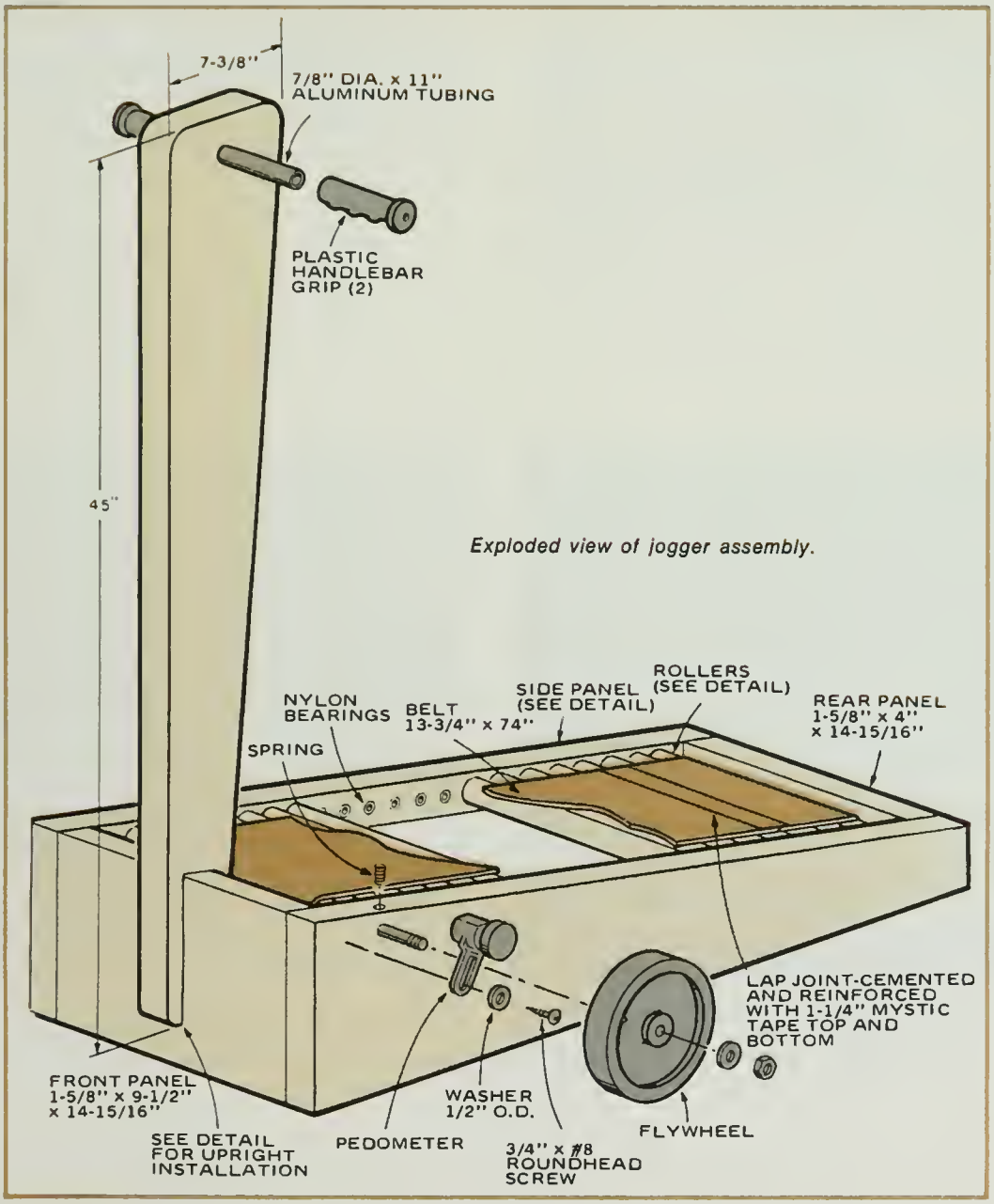
extension ladder: see ladders
extension speaker: see stereo
exterior house painting: see painting, house
faltering starter: see engine
fans: see ventilation

rivets) are driven into the ends of the rollers to form roller shafts.

The front roller and rear tension roller are made up of 14¾-inch lengths of 1¼-inch O.D. aluminum tubing, with 1⅛-inch hardwood plugs, ¾-inch thick, inserted at each end. A ⅜-inch hole is drilled through the center of each plug. A ⅜-inch diameter steel rod, 18⅜-inch long, is inserted through the front roller so that it extends 3⅜-inch out of one end, ⅜-inch out the opposite end. A similar rod, 15½-inch long, is inserted through the rear tension roller, with ⅜-inch extending out of each end.

To facilitate roller assembly, it is necessary to temporarily nail two strips of wood to the rollers to hold them in position when they are properly aligned. To accomplish this alignment, make up the positioning jig.

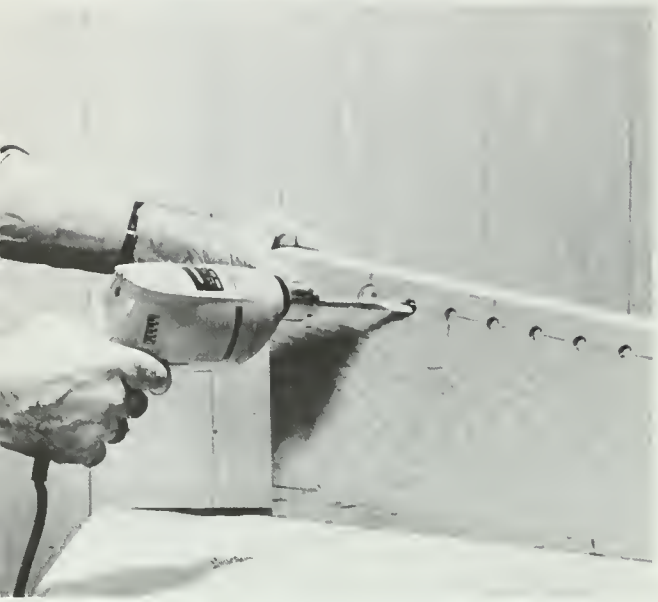
Place the first four rollers in position with a jig at each end, and nail the two



Exploded view of jogger assembly.

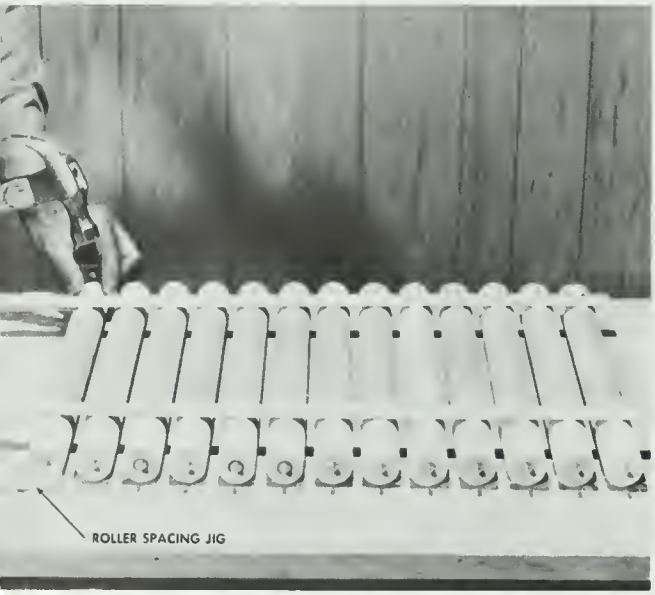
1016

Easy-to-build Jogging Machine

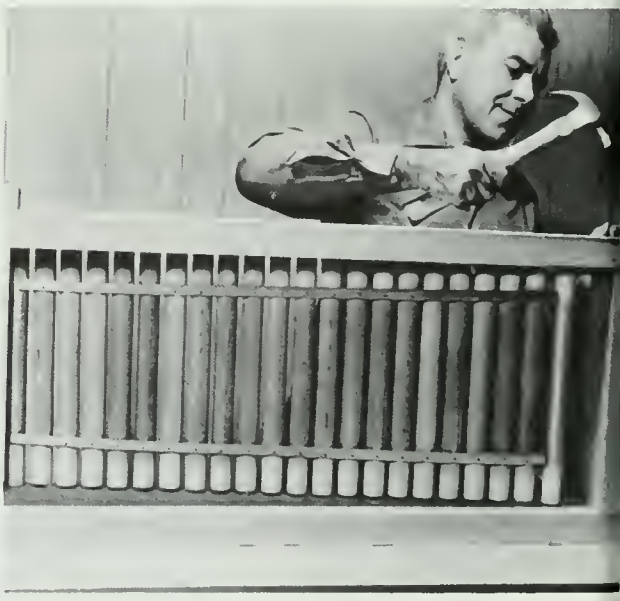


Cut lumber to size, lay out bearing hole placement and drill holes accurately. Put mark on drill bit so depths will be uniform.

Nylon bearings are inserted in holes with narrow end first. Tap gently with hammer to seat them flush with surface of wood.



For final assembly, two wood strips are temporarily nailed to rollers. To space rollers accurately, make space jig.



After side panel is in place, raise ends slightly to apply glue then nail into spot securely. Remove strips nailed to rollers.

strips in position so they can be installed as a unit. Use brads, and allow the heads to extend slightly so the brads can be removed later. As you add rollers, move the jig forward to maintain proper spacing.

Attach front and rear panels to one side piece after placing a rear tension roller assembly in its socket. Use glue on mating wood surfaces, and fasten the panel with nails. Set all nail heads below the surface of the wood, and cover them with wood filler. Turn the entire assembly on its side so that front and rear panels stick straight up.

Now pick up the rollers as a unit, and insert them into their respective bearings in the side panel. Hold a rear roller tension assembly in place in the second side panel, carefully align the panel, and drop it into place over the rollers. You can lift each end slightly to apply glue to mating surfaces, then nail the side panel in place. Remove the two strips previously nailed to the rollers; all should now turn freely.

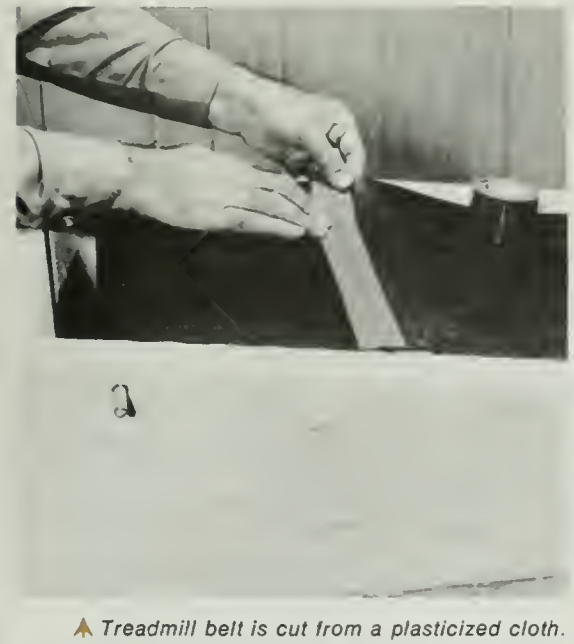
Cut the treadmill belt from a piece of plasticized cloth. The cut size for the belt is 13¾-inch x 74-inch. Note that most of the plasticized cloth materials stretch in one direction; make sure that stretch is sideways, not lengthways.

Place cloth around the rollers in a snug fit; the lap joint of the belt is held with contact cement. Cloth tape, 1¼-inch wide, is used to reinforce the joint.

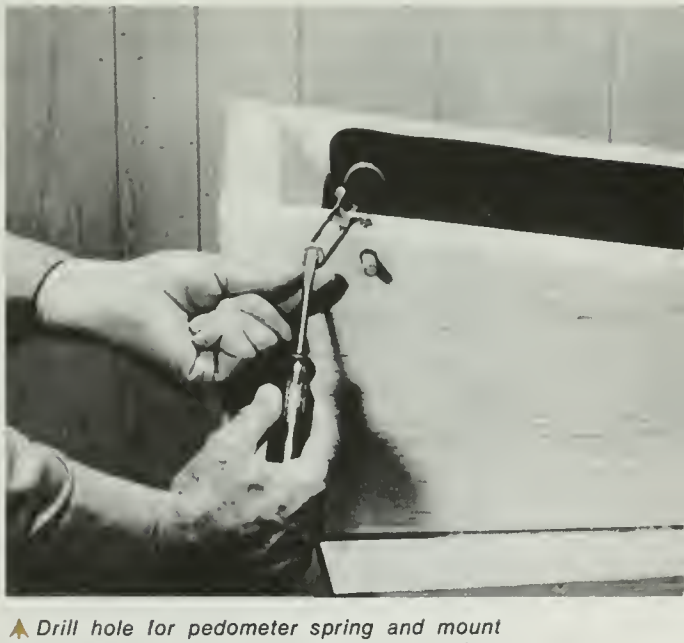
Insert washers and wing nuts on the ends of the two tensioning eyebolts. Treadmill tension and tracking are adjusted by tightening or loosening the wing nuts. If the treadmill tracks to one side, tighten the opposite wing nut.

Drill the hole for the pedometer spring, and mount the pedometer using a round head screw and a washer. Do not tighten the screw all the way, as the pedometer bracket must be free to ride up and down to follow the flywheel rim.

Mount the flywheel on the roller shaft, with the sponge rubber disc of the pedometer riding against the inner rim.



Treadmill belt is cut from a plasticized cloth. Be sure stretch is sideways, not lengthways. Lap joint is held with cement.

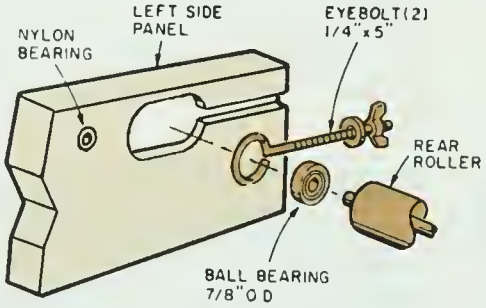


Drill hole for pedometer spring and mount pedometer using round head screw and washer. Do not tighten the screw all the way.

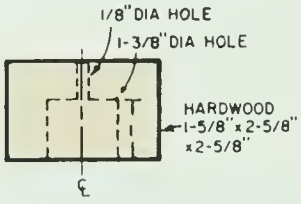
MATERIALS LIST

Quantity	Size and Description	Purpose
2	1⅝" 9½"x42" fir hardwood	side panels
1	1⅝" 9½"x14¹³⁄₁₆ fir hardwood	front panel
1	1⅝" 4"x14¹³⁄₁₆ fir hardwood	rear panel
1	1⅝" 7⅜"x45" fir hardwood	upright
2	1¼"O.D.x14¾" aluminum tubing	front and rear rollers
4	1⅛"O.D.x⅜"I.D.x¾" hardwood plugs	front and rear rollers
1	⅜" dia.x18⅜" cold rolled steel rod	front roller
1	⅜" dia.x15½" cold rolled steel rod	rear roller
20	1⅜" dia.x14¾" fir closet poles	rollers
40	⅜" dia. nylon bearings	
4	⅞" O.D. ball bearings	

NOTE: Also need eyebolts, round head screws, washers, lag screws, plasticized cloth, flywheel, aluminum tubing for handlebars, plastic handlebar grips, pedometer with spring and sponge rubber disc.

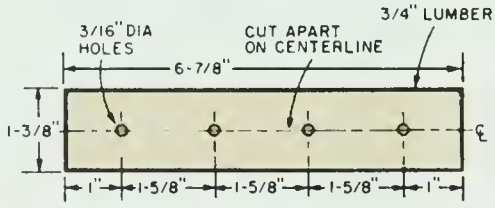


DETAIL A

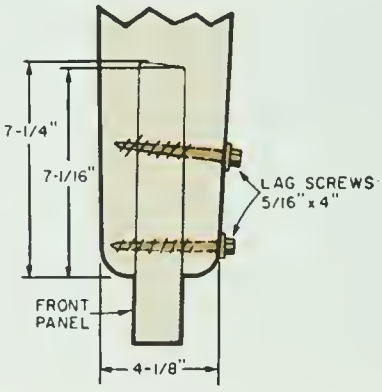


DETAIL B
ROLLER PILOT HOLE DRILLING JIG

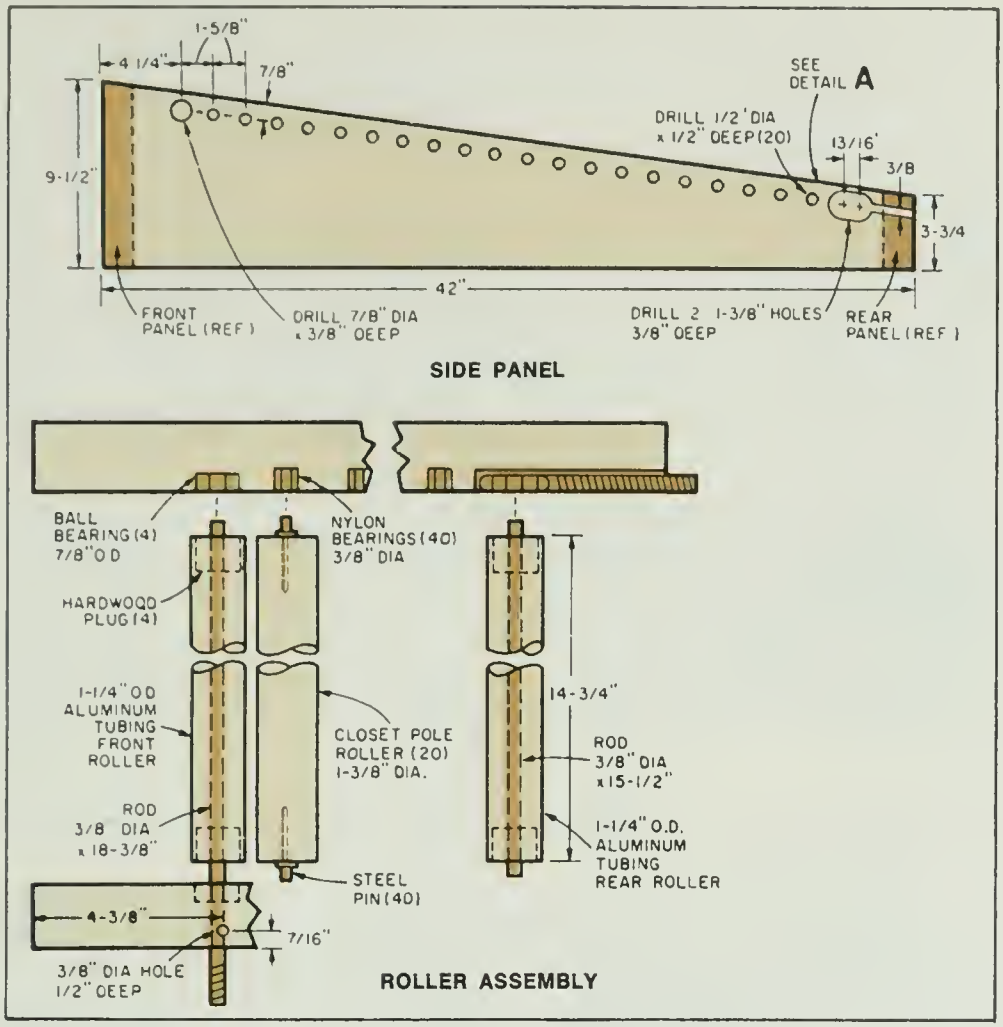
Slot for threaded section of eyebolt can be cut with a saw as shown in Detail A. Detail B illustrates how jig is made up for drilling pilot holes in the ends of rollers. Roller spacing jig (Detail C), is used to facilitate roller assembly. Also shown is a detailed view of the upright installation.



DETAIL C
ROLLER SPACING JIG



UPRIGHT INSTALLATION



▲ *Bearing hole locations on inside face of side panels and detail of roller assembly.*

Mileage is indicated on the pedometer dial, with 400 revolutions equaling one mile.

Cut out and install the upright. A ⅞-inch hole is drilled at its upper end for the handlebar, and a slot is cut at the lower end that slips over the front panel. Work carefully, as this should be a snug fit. Fasten it with two 5/16-inch x 4-inch lag screws installed from inside the framework, after drilling pilot holes. Note that the upper screw goes in at an angle to clear the front roller.

Insert a ⅞-inch O.D. aluminum tube, 11 inches long, through the hole in the upright, and install handlebar grips on each end. Now you can finish the jogger with the paint scheme of your choice. Use at least two coats of paint, and sand lightly before each is applied.

Original design by Steve Ellingson.

WHERE TO FIND IT

If your local dealer cannot supply them, the flywheel, nylon bearings, ball bearings, steel pins, and pedometer can be ordered from The Armor Co., Box 290, Deer Park, N. Y. 11729.

Rowing Exercise in Your Home

This easy-to-build rowing machine will provide you with spare time pleasure and help you stay trim at the same time

WE CAN ALL use a little healthy exercise. An easy building project will help limber you up, and a good rowing machine will help keep you in trim. The project and machine are combined in the Row-Er-Ciser. With its rowing handle and sliding foot rests tensioned by four 20-pound-pull springs, you are guaranteed to get a good workout.

Although this project looks complicated, its construction is fairly simple. Easily-obtained materials, common hand tools, and just a little bit of skill are all you need.

You can make up your own full-size patterns. Trace the patterns on the wood stock, and cut out the pieces. Use a saber saw or jig saw for the curved sections.

Start with the rear panel. Drill pilot holes for the four screw eyes, and install them. You can use a heavy nail or an awl to turn them in all the way. Cut out the two side pieces, and mark the location for the $\frac{5}{16}$-inch hole on one of them. Clamp the panels together, and drill the hole through both. Assemble the rear, bottom, and sides, using 1½-inch #8 flat head wood screws, after coating mating surfaces with glue. Be sure to drill pilot holes for all screws, and countersink the screw heads.

Drill two $\frac{5}{32}$-inch holes through each of the two 33-inch lengths of aluminum tubing. These tubes are 1-inch in diameter, and one is fastened to the inner face of each

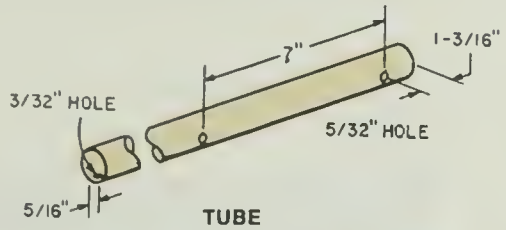
side piece, with 1½-inch #8 round head screws through the $\frac{5}{32}$-inch holes.

Make up two spacers. Each is made of two ¾-inch thickness of hardwood, glued together. The spacers should be about 1¼-inch in outer diameter (although the round shape is not necessary), and a $\frac{5}{16}$-inch hole should be drilled through the center of each.

Next, assemble the push lever. It is a $1\frac{11}{16}$- x 23¾-in length of ¾-inch stock with a ⅞-inch hole drilled through the upper end to take the handlebar. Drill a ½-inch hole for the $\frac{5}{16}$-inch I.D. bushing, and the two ¼-inch holes at the lower end of the stock, as shown. A ⅛-inch slot, 2½-inch deep, is cut in the lower end.

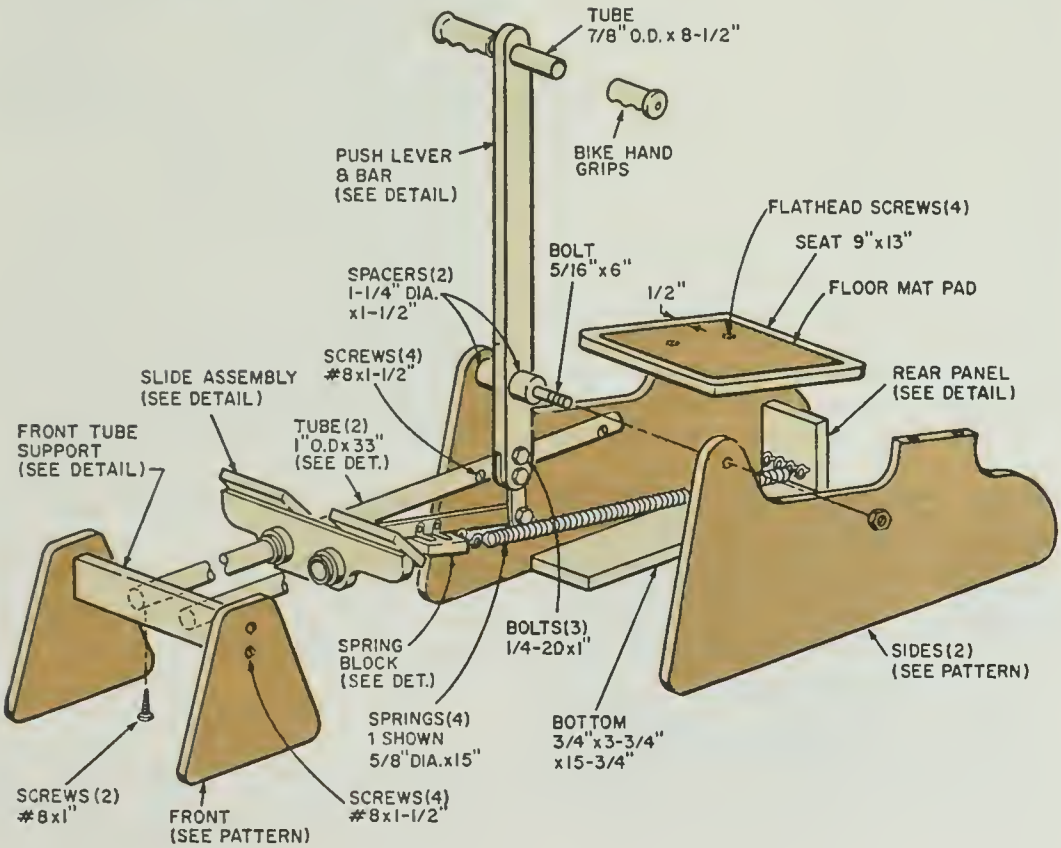
The push lever bar is made by rounding off the end of a ⅛- x ¾- x 5¾-inch steel bar. Drill a ¼-inch hole at the rounded end, and slide the square end into the slot in the push lever. Using the two holes in the lever as guides, mark the bar, remove it, and drill ¼-inch holes where marked. Assemble the bar to the lever with ¼-inch—20 x 1-inch bolts with lock nuts.

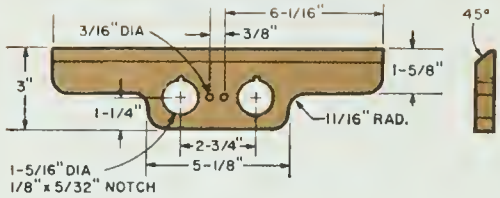
Now assemble the push lever to the side



TUBE

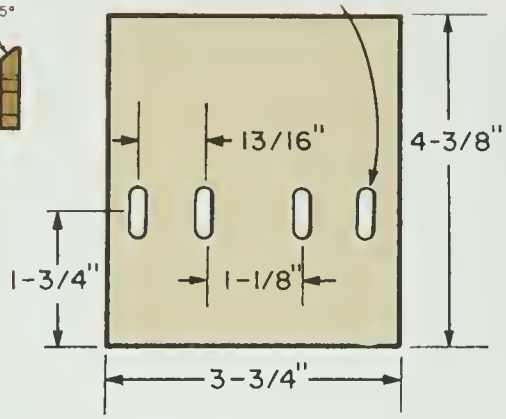
Without two tubes detailed in top left drawing, you would get no rowing exercises. Tubes allow foot brace to slide back and forth as handle is pumped. Unit is made of easily obtained material.





SLIDE

Rear panel, carries brunt of pull pressure of springs. Foot pedals are fastened to 45° slanted top edge of slide as shown. Holes must be accurately drilled.

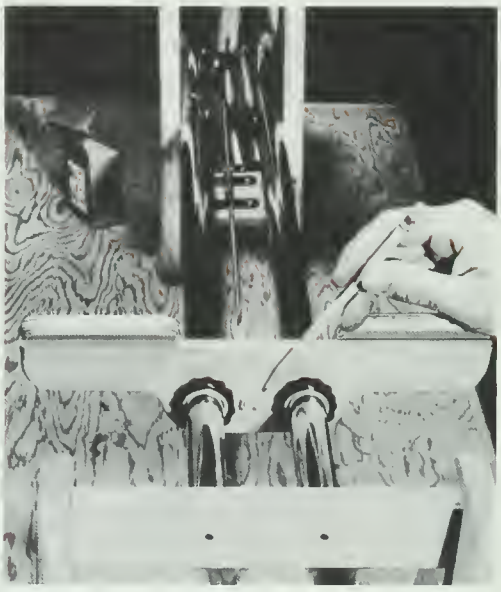


REAR PANEL

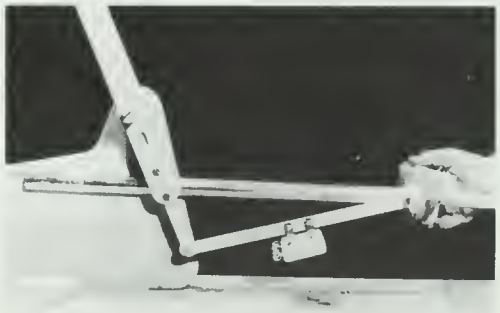
pieces. A $\frac{5}{16}$-inch x 6-inch bolt is inserted through one side piece, a spacer, then the bushing on the push lever, the second spacer, and the second side. Be sure to use a lock nut on the bolt.

The spring block assembly is made next. The spring block bar is a 14⅛-inch length of ⅛- x ¾-inch steel stock, rounded at each end. Drill the ¼-inch holes at each end, and the two $\frac{3}{16}$-inch holes near the center, as shown. The spring block itself is ¾- x 2½- x 3⅝-inch hardwood, with the corners rounded slightly by sanding. Drill pilot holes on the rear edge for the four screw eyes, and install them.

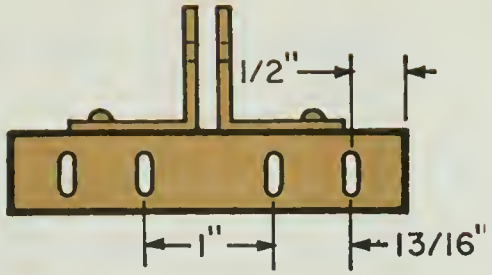
Mount four ½- x 1- x 1-inch angle



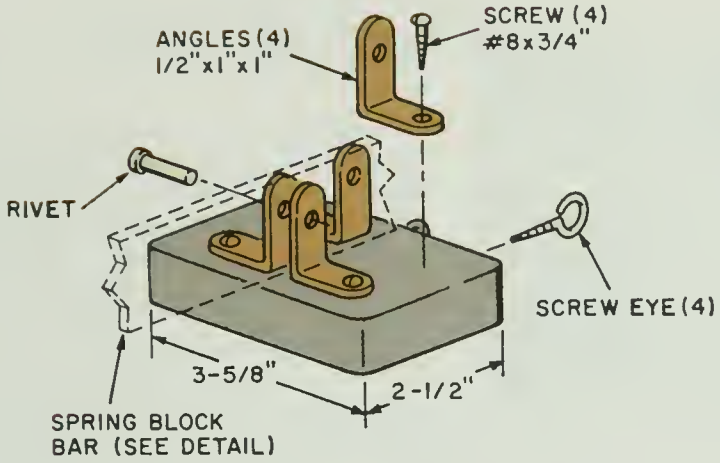
Pencil points to holes for "eye bolts" to which bolt serving as anchor and axle for slide bar is fastened.



With one side panel removed it's easier to see how push lever is mounted and articulated with spring block bar and spring block assembly and their relation to the slide bar and tubes.

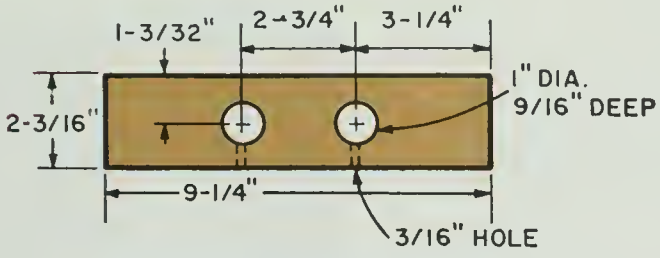


BACK VIEW

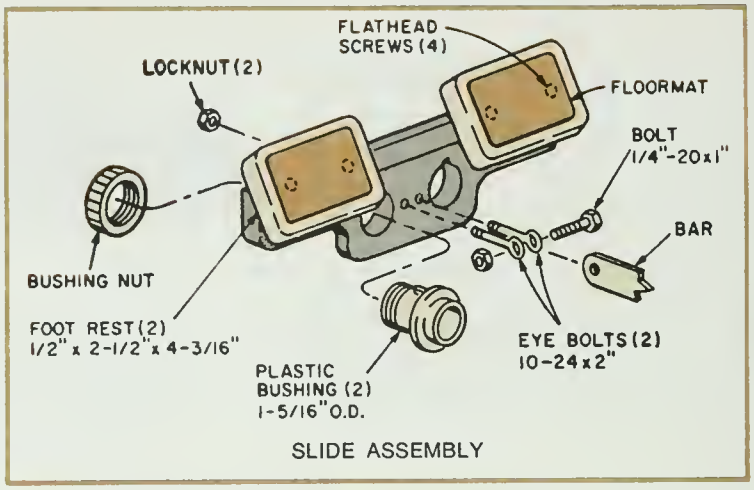


SPRING BLOCK ASSEMBLY

Back view (upper) and general view of spring block bar (lower) detailing its assembly drawn above and front tube support below.



FRONT TUBE SUPPORT
(Rear View)



➤ *Plastic bushings mount in slide bar as shown and make slide bar easy to move over tubes. Their mounting holes must be accurately drilled and must be parallel. Foot pedals are made from scraps of wood covered with scraps from rubber floor mat. Eye bolts require locknuts to keep them tight in position.*

▲ *Photo shows one of two spacers, made of two pieces of ¾-inch plywood that keep push lever centered on its mounting bolt.*

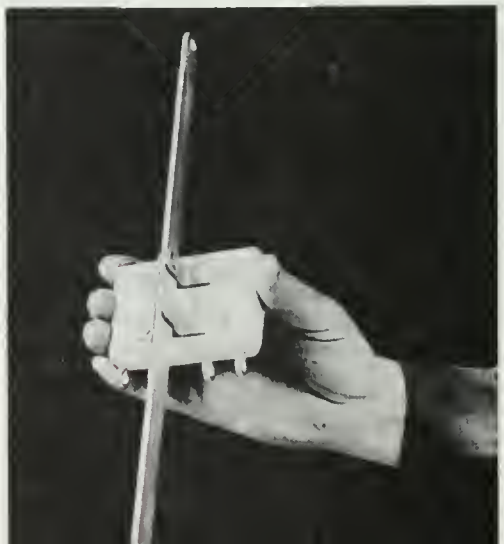
brackets on top of the block, and bolt them to the spring block bar. If you have the equipment for rivets, you can install them, but bolts will work just as well, if used with lock nuts.

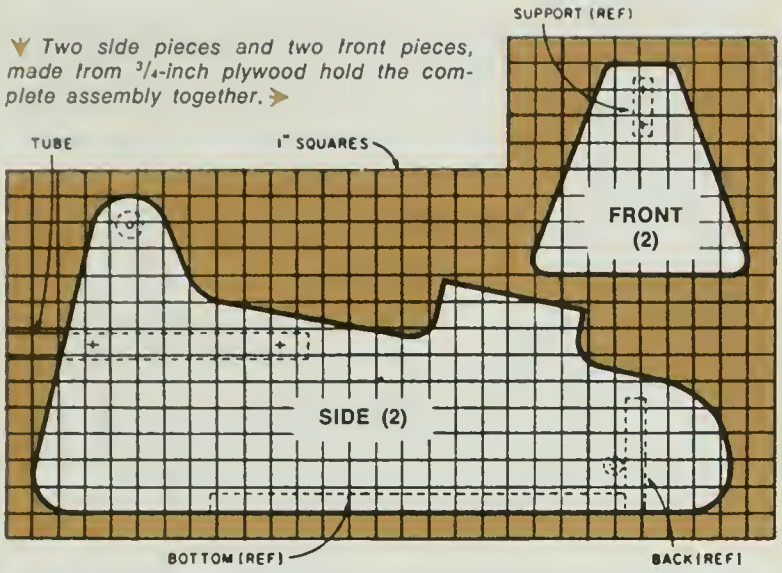
The wood slide is cut from ¾- x 3- x 12 9/16-inch hardwood stock. Bevel one top edge as shown. Drill the two 1 5/16-inch holes, and at the top of each cut a ⅛-inch wide notch, 5/32-inch deep. Drill two 3/16-inch holes near the center of the side, and install a 10-24 x 2-inch eye bolt through each, with lock nuts. The eye rings should be vertical. Insert a plastic bushing in each of the large holes, matching the keys on the bushings with the slots. Plastic ring nuts are used to hold the bushings in place.

Now insert the two aluminum tubes through the bushings. Slide the front end of the spring block bar between the two eye bolts on the slide assembly, and fasten with a bolt that passes through the two eyes. Bolt the other end of the spring block assembly to the push lever bar.

Drill 1-inch holes in the front tube support, and 3/16-inch holes up from the bottom, as shown. Cut out the two front support side pieces and fasten them in place with 1½-inch #8 flat head wood screws. Always drill pilot holes and countersink screw heads. Insert the two aluminum tubes

▼ *Spring block assembly is mounted to spring block bar.*

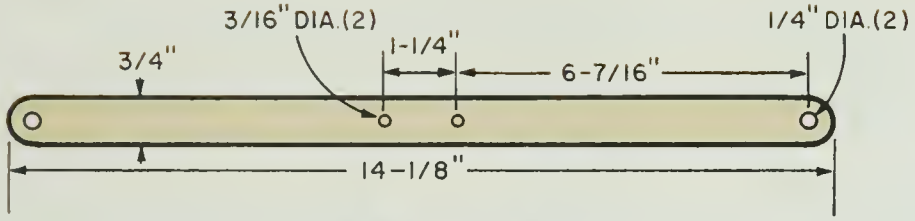




Two side pieces and two front pieces, made from 3/4-inch plywood hold the complete assembly together.

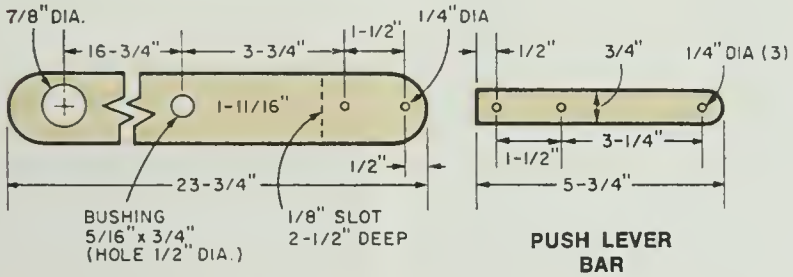
into the front support so their ends are flush with the front face of the support. Use a nail or scribe, and mark the tubes through the $\frac{3}{16}$-inch holes. Remove the support, drill $\frac{5}{32}$-inch holes in the tubes where marked, and re-assemble using 1-inch #8 sheet metal screws run through the $\frac{3}{16}$-inch holes into the tubes.

Make up the two foot rests, and screw them to the beveled edge of the slide, using



SPRING BLOCK BAR

Spring block bar is connecting link between push bar and push springs and slide which makes rowing action possible. Push lever is assembled to push bar.



PUSH LEVER

PUSH LEVER BAR

MATERIALS LIST

Quantity	Size and Description	Purpose
1	3/4" 9"x13" plywood	seat
2	3/4" 12"x26 5/8" plywood	sides
1	3/4" 3 3/4"x4 3/8" plywood	rear panel
1	3/4" 3 3/4"x15 3/4" plywood	bottom
1	3/4" 1 1/16"x23 3/4" hardwood	push lever
1	3/4" 2 1/2"x3 5/8" hardwood	spring block
1	3/4" 3"x12 5/16" hardwood	slide
3	3/4" 8"x8 1/8" plywood	front support sides
1	3/4" 2 3/16"x9 1/4" hardwood	front tube support
2	1/2" 2 1/2"x4 3/16" plywood	foot rests
2	1 1/4" dia.x1 1/2" hardwood	spacers
2	1"O.D.x33" aluminum tubing	slides
1	7/8"O.D.x8 1/2" aluminum tubing	handle bar
1	1/8" 3/4"x14 1/8" steel bar	slide assembly
1	1/8" 3/4"x5 3/4" steel bar	push bar
as needed	1 3/8" screw eyes	
as needed	10-24x2" eye bolts	
as needed	#8x1" sheet metal screws	
as needed	#8x1 1/2" flat head wood screws	
as needed	#8x1 1/2" round head wood screws	
as needed	#8x3/4" round head wood screws	
as needed	1/4-20x1" bolts with lock nuts	

NOTE: Also need 5/16"x6" bolt, angle brackets, bike hand grips, rubber floor mat, 20 lb. pull tension springs, high impact plastic bushings and bronze bushing.

1½-inch #8 flat head wood screws. Pieces of rubber mat can be cut slightly smaller than the foot rests, and glued in place with a good contact cement.

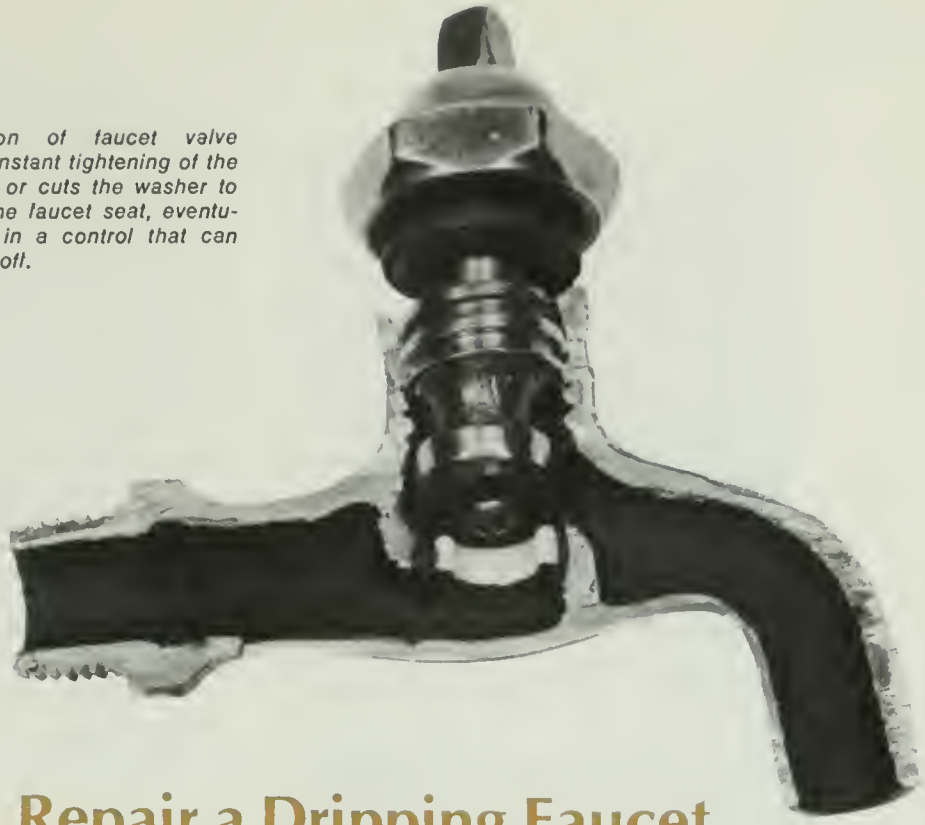
The seat is cut out of ¾- x 9- x 13-inch plywood. Center it in place, and attach it to the top of each side piece with two 1½-inch #8 flat head screws. Rubber floor mat, trimmed ½-inch narrower than the seat all around, makes a comfortable, non-skid surface. Glue it in place with contact cement. Install the ⅞-inch diameter aluminum tube handlebar through the hole in the upper end of the push bar lever. The handlebar grips will slide on easily if heated for a few minutes in hot water, and they will keep the handlebar centered.

Finally, sand all wood surfaces, and paint the Row-Er-Ciser. Use at least two coats of a good enamel, and sand between coats for best results. If you want to get fancy, use two or more colors. Apply the lightest shade first, and when dry, protect it with masking tape before applying a darker color. Remove the tape while the second color is still wet.

Original design by Steve Ellingson.

WHERE TO FIND IT

The tension springs, plastic bushings, and the bronze bushing for the push rod lever can be ordered from The Armor Co., Box 290, Deer Park, N. Y. 11729.



➤ *Cross-section of faucet valve shows how constant tightening of the handle grinds or cuts the washer to bits against the faucet seat, eventually resulting in a control that can never be shut off.*

How to Repair a Dripping Faucet

If leaky faucets are keeping you up nights, try these simple, speedy repairs and rest peacefully from now on

SOME FAUCETS keep going year after year in perfect working order without the slightest attention. Others act as if they are pixilated—they gulp washers galore without showing any appreciation, drip constantly, are hard to open and still tougher to shut off.

It requires little effort to get all the faucets in your house to perform properly, which means that they open and close smoothly and without effort, control the flow of water to the degree that you want it, make no objectionable noises, and keep going for long periods without any attention.

New styles. Faucets are becoming more attractive in appearance, more efficient—and more complicated. Formerly a faucet disassembly required merely removing a single lock nut and the entire works came out, consisting of a worm-thread stem with a washer cup at the bottom.

Now we have one-arm faucets, dish spray hoses, three-valve shower diverters, kitchen counter-sets, and a whole array of new styles, some of which have 15 to 20 separate parts that must be put together in the right order.

The fundamental process of washer replacement applies to nearly all faucets except the one-arm kitchen model.

Often, replacement of washers is neglected because it involves shutting off the house water main and draining the lines. This problem is completely eliminated by having separate shut-off valves at every fixture. These are easily installed at lavatory sinks, as described later.

Replacing washers. Use a monkey

faulty flush tank: see toilet
feeders: see bird feeders
felt: see yarn

wrench, or channel lock pliers with smooth jaws to loosen the bonnet nut. In most cases, this will permit removal of the stem just by twisting the faucet handle.

In some models, it is necessary to lift off the handle after turning out the screw at the center. (If there is a plate covering the screw, remove the plate.)

When working with the decorative faucet parts, use care not to scratch or dent the chrome surfaces. If necessary, protect the finish from the wrenches with a cloth or masking tape.

The washer is at the bottom of the stem. Remove the screw that holds the washer in place, being careful not to snap it off.

If the screw slot is corroded, or partly broken, ease it loose with pliers. If screw head is gone, pry up the washer, exposing a part of the screw stem that can be gripped with the pliers.

Remove the washer from its brass cup. Clean out the cup with a brush or knife, and select a new washer to fit.

Faucet stem has cup at the bottom, into which the washer is held with a brass screw.

There is no practical difference between the black, white, gray, and red washers—the colors are only for merchandising purposes. Select a neoprene or hard rubber washer for a snug, but not tight, fit. It may not be possible to tell the size from the original washer because of distortion.

Make certain the brass screw is turned in tightly so it can't work free and drop out. Also, a loose washer will cause chattering of the faucet when water is turned on. Use a new brass fastener each time you make a washer replacement. Put the stem back into the faucet body, tighten the bonnet nut, and the job is done.

Turn the faucet handle tightly a couple of times to help seat the washer, then open the water valve.

Washer sizes. While you are at it, make a note of the size washer used for the fixture, so you can buy replacements to keep on hand. It is not worth buying the usual hardware store assortment because most of the washers included will never be used.

Once you list the needed sizes for your house fixtures you can stock up with only the sizes required.

There are several types of washers, some offered as a panacea for every faucet trouble. The domed type usually functions better than the flat because it compresses against the lip of the seat as well as on the flat surface, though you will find these washers flatten out eventually in use.

Non-rotating washers have an advantage because they move up and down with the stem rather than being twisted at the point of compression. The non-rotating type with a stem that fits into the washer screw hole is better because it can be removed when necessary, while the free-floating type may become jammed against the seat, making it difficult to reach for removal.

Smoothing faucet seat. If the faucet still drips after the washer is replaced, it indicates that the washer seat is nicked or scratched. This happens sometimes because

of a particle of sand or some other matter in the water line.

A low-cost seat dressing tool will quickly smooth the seat for better closure.

Open the faucet as before, take off the handle, slide up the bonnet nut, and remove the stem. Place the dressing tool into the faucet body, with the knurled nut adjusted to permit threading of the bonnet nut back into position. The bonnet nut holds the dressing tool shaft straight and exerts slight pressure while it is rotated. Make just one or two turns, then remove the tool.

Before reassembling the faucet stem, open the water valve just for a moment to flush out brass chips left by the dressing operation. Then replace the stem, reassemble the bonnet nut and handle. Try the faucet to see if the drip has stopped.

Continuation of the drip means that the washer seat is badly corroded or chipped. Most better-quality faucets have replaceable seats which look like shallow brass rings with threaded base, rounded at the top. These seats are turned out with a narrow-blade screwdriver or an Allen wrench.

A parts catalog from the manufacturer of the faucet will show whether the seat is removable and indicate the part number for replacement. If possible, get the new washer seat before removing the old one so it can be replaced immediately without tying up the faucet. You may be able to match the seat at a plumbing supply dealer who stocks these parts.

Faucets that do not have a replaceable washer seat sometimes can be repaired with a special insert of soft brass which is placed over the old seat to provide a new smooth surface. This may work for a while, but will deteriorate quickly under the constant rotation of the washer.

The best correction, then, is to replace the troublesome faucet with a new one—of the latest type.

Worn faucet stems. When force must be exerted on the faucet handle to shut off the water completely, it indicates that the stem gear is worn.

Cutaway of faucet section shows how Allen hex wrench is used to remove washer stem.

Gain access to tub and shower controls by removing the escutcheon plate which covers the faucet stem.

Most hardware dealers carry a large selection of faucet stems and probably can match yours. If unable to get one locally, write to the manufacturer for a source.

The packing washer around the stem may become worn or enlarged so water

seeps up around the stem when the faucet is open. Remove the old packing, stripping it away in sections, and press on a new washer of proper size.

If a washer cannot be obtained, wrap graphite-coated wicking around the stem and tighten with the bonnet nut to stop the leak.

Some bathtub and shower faucets are recessed into the wall tiles, and are removed only with a deep socket wrench, after taking off the handle and escutcheon plate.

Adding sink valves. Individual valves are easily installed at fixtures with the aid of a valve set. These sets consist of a small angle valve, flexible inlet riser tubing with compression fitting, and a reducer bushing.

A valve installation for a bathroom sink can be done in the following manner, once the water is turned off at the main.

Remove old connection pipe from wall to sink faucet. If the sink is of modern type, a special basin wrench will be needed to loosen the connecting nut underneath the faucet. The water entry line, in most cases, ends close to the wall. When the top nut is loosened, turn the pipe out of the right angle elbow, then remove the horizontal section connecting to the entry pipe.

Install a coupling on the entry pipe. If pipe is ¾-inch, use a ½-inch reducer coupling. Turn the angle valve on a nipple which is of a length that, when turned into the entry coupling, will bring the valve riser directly under the faucet opening below the sink. Put escutcheon plate over the horizontal nipple before installation.

Measure the flexible riser in position against the valve and cut to length with a tubing cutter.

Push riser into valve part and tighten the slip nut. Force the other end into the faucet opening (there is sufficient flexibility of the tube for this) and tighten the compression nut.

At a nominal cost, the faucets now have an individual shut-off valve that saves considerable trouble whenever repairs must be made. Each lavatory, sink, water closet tank and shower should be equipped with individual valves for the hot and cold water lines.

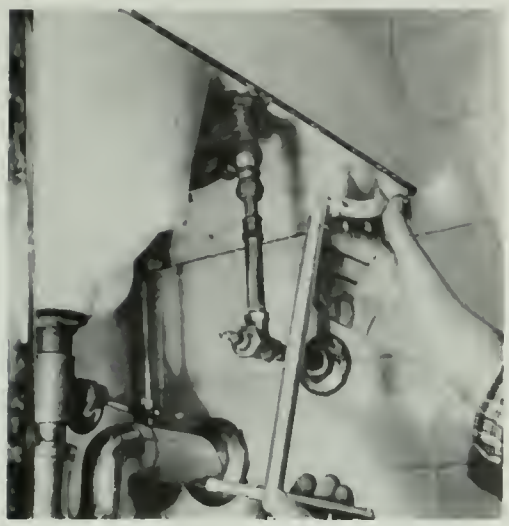
▲ *Deep socket wrench might be necessary to remove faucet stems that are recessed in the wall.*

Valve repairs. There are a number of valves used in the average home system. Gate valves are usually for the service entrance and the main water branches, as they allow direct passage of the water with minimum drop in pressure. These valves are intended only for infrequent use, and generally are kept fully open.

Globe and angle valves are used to control the flow of water (for example, the mixing valve at a water heater) and thus are adjusted quite frequently.

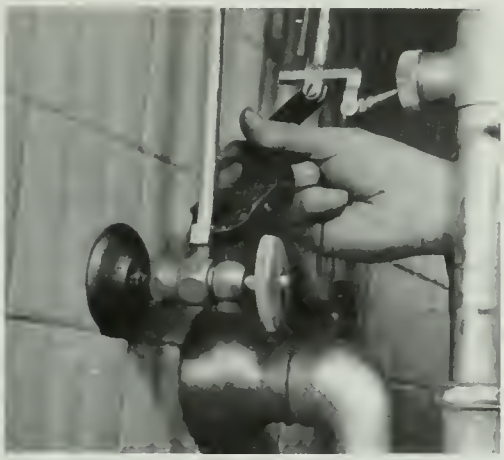
Globe valves may leak at the stem, which will require repacking. This is done by loosening the packing nut so it can slide up on the stem sufficiently to allow threading the graphite packing underneath. Pressure of the cap usually seals the space and stops leaks.

When the washer must be replaced, the water main is closed down and the lines drained. The stem is removed similarly to a faucet by turning off the packing nut and

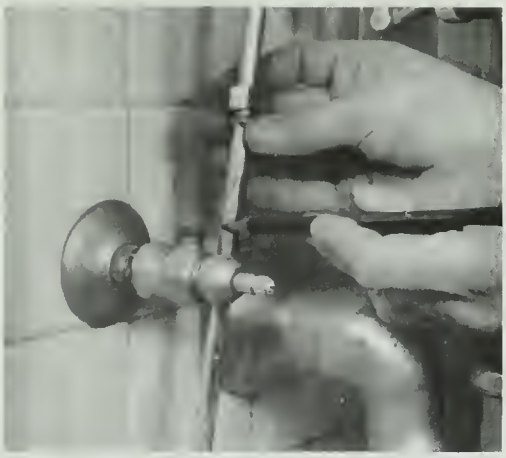


When replacing lavatory faucets, use a basin wrench to remove retainer nut from underneath.

Wrap lamp wicking or apply plumbers compound to the stud to provide a watertight seal for temporary leak repairs.



After the nut is started, tighten tube to valve by turning compression nut with wrench.



Measure and cut the riser tube to required length. Leave enough stock to go into the fitting.

bonnet. A composition fiber washer is fitted into the stem cup, held with a brass screw.

Globe valves should be installed so that when closed, the pressure will be against the stem so the packing can be replaced while there is pressure in the line.

Pipe hangers should be placed on each side of the valve so no strain or weight of the pipe is carried by the valve. A bowed condition will result in unequal strain on the threads and, in time, result in a leak that can only be checked by replacing the valve, pipes, or both.

Globe valves should be set with the stem in a horizontal position when possible. Gate valves should be set with the stem in a vertical upward position, or at a 45° angle so scale and sediment will collect on the bottom.

See also: PLUMBING.

Replacing Your Kitchen Faucets

The old chore of replacing a kitchen faucet is now far easier with inexpensive kits

IF YOUR KITCHEN SINK faucet is so worn that replacing washers and smoothing the valve seats do little or no good, or if you would simply like to replace an old-fashioned faucet with something more modern, you can do the job yourself.

If the replacement unit is virtually identical to the one you have now, all you have to do is remove the old fixture and substitute the new one, using the existing piping. If you elect to switch to a fixture of different design, more work may be involved. For example, if you now have a dual-control faucet with a feed line going directly to each valve system, but you want to switch to a washerless style fixture wherein both hot and cold feed lines enter at the center of the fixture, some alteration of the main feed lines under the sink may be required. However, these alterations are quite simple to make, provided you plan your work carefully.

Faucet designs have changed considerably in recent years, and undoubtedly the most notable advance has been in the development of washerless faucets which are guaranteed for ten years. You can still purchase a washer type faucet, but consider seriously paying a bit more to get a washerless type. These are available in single-lever or dual-control models.

Before shopping for a new faucet, examine your present plumbing, noting especially whether you need a fixture having a 6- or 8-inch separation of the feed lines. If you choose a fixture having both feed lines centrally located, the soft copper tubes can be hand bent to fit any separation of the main feed lines. However, you may have to shorten the main feed lines a bit to make the connections.

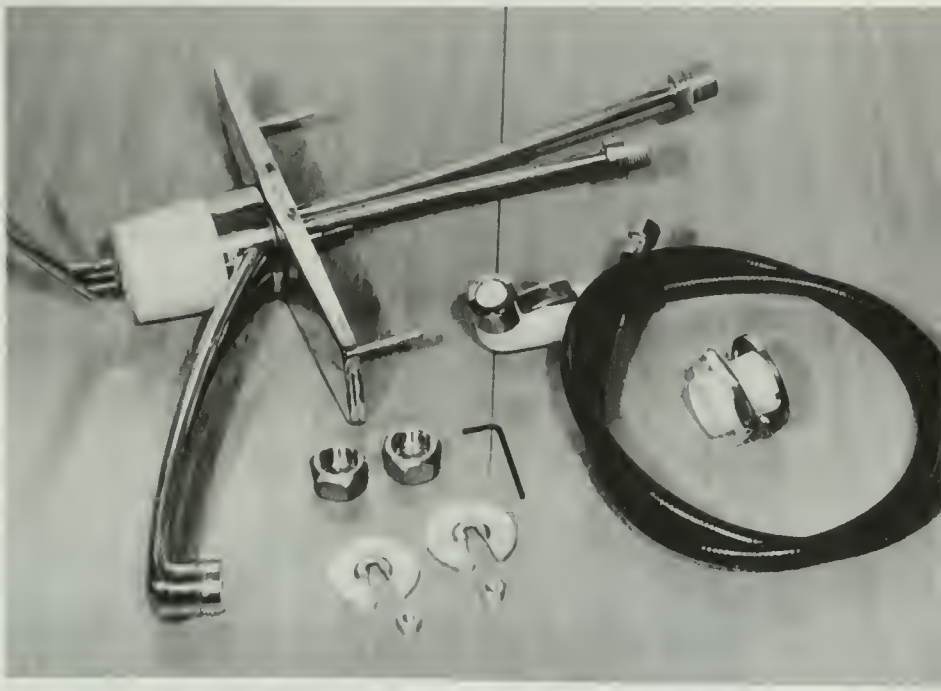
Removing the old fixture. First cut off both hot and cold water supplies by closing the valves you should find under the sink, or perhaps in your basement. Open both faucet taps to be sure that the water is cut off. The washer in a cut-off valve may be defective, and you may have to replace it before starting work on the faucet. Just shut off the main water valve (near the water meter) to replace a washer in a sink cut-off valve.

Now disconnect the faucet from the water feed lines by carefully loosening the nuts under the sink. Do not damage these fittings because you will probably want to use them again. If you cannot get into the cramped space behind the sink with an ordinary

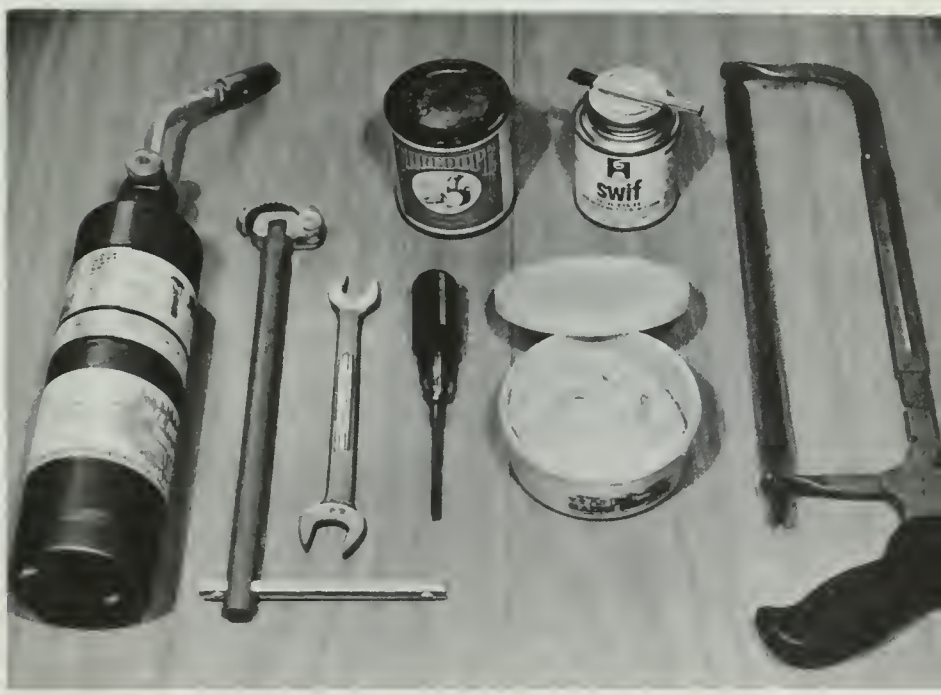
wrench, buy a basin wrench from your local hardware or plumbing supply dealer. It can be well worth the low price.

The nuts holding the original faucet to the sink may be frozen so tightly, because of corrosion, that no wrench will remove them. The easiest solution is to drill through the nuts using a hand power drill and a quarter inch bit. The nuts will then break off easily.

Altering feed lines. Drop the new faucet into place to see what must be done to make it fit the existing plumbing. It is possible that all you need do is reconnect the



➤*One complete faucet kit includes: faucet assembly, connecting nuts and washers, rinser hose, hose guide, and an Allen wrench for tightening the faucet handle set-screw.*



➤*Only a few simple tools are required. Hacksaw, propane torch, and paste solder are needed only if water feed pipes require alteration. Pipe joint compound makes threaded joints leakproof. Plumber's putty is the sealant for the base and the sink.*

faucet inlets to the existing line. Or you may have to shorten the main feed lines to make connections possible.

If the vertical feed tubes are too long, remove them by unsoldering at the first joint. This is done easily by heating the joints with a propane torch while twisting the tubing gently with a small pipe wrench. The tubes will become quite hot, so tie a stout cord to the upper ends so that you can pull the tubes out without touching them by hand.

After both tubes are out, measure them carefully to determine how much must be cut off at the lower ends that were unsoldered. Cut the tubes cleanly, straight across, using a tubing cutter or a fine-tooth hacksaw. File off any burrs.

Clean the tube ends for resoldering by rubbing with steel wool. Do not use a file which could take off too much metal and lead to a loose fit.

The easiest way to resolder is to use *paste* solder which already contains flux. This type of solder is sold at plumber's supply shops. Just brush the paste onto the tube end, twist gently into place, and heat the joint with a propane torch until a black ring forms at the joint. You may also see a few small beads of silvery solder emerge from the joint. To be doubly sure of a good seal, flow a bit of wire solder all around the joint.

Final installation. Read the installation instructions that come with your fixture and follow the steps in proper order. For example, you may be told to attach the rinser hose to the fixture before mounting the fixture on the sink. Be sure to use pipe joint compound on all threads to obtain leakproof seals.

A little plumber's putty should be put along the bottom edge of the fixture before installation to prevent water from seeping under the fixture where it would hasten corrosion. Now fasten the faucet to the sink,

Attach rinser hose before installing the faucet onto the sink. Apply pipe joint compound to the threads first, to get a leakproof seal. Remove spray-head so hose can pass through opening.

▲ *If copper feed tubes require alteration, use propane torch and plumber's brush-on paste-solder to make perfect solder joints.*

attach the water lines, and complete assembly of the rinser if it is provided with your new faucet.

Testing the work. Turn on the water supply and check all joints carefully for leaks. Check operation of the faucet. If it does not function properly, consult the manufacturer's directions to see how the faucet is taken apart for inspection. When the unit shown here was tested, not a drop of either hot or cold water would come out of the faucet. The problem was caused by a small amount of debris caught in a part called the "lift diverter." The debris may have been washed into the diverter during the first rush of water. When the particles were removed, the faucet functioned perfectly.

The point is this. If your fixture does not work perfectly the first time, do not immediately call in a plumber or return the fixture to the store. A few minutes of logical trouble-shooting is all that is needed to solve the problem.

One final tip: If you find that the sink *drain* piping is in your way when you work on the faucet plumbing, remove it temporarily as far as the U-trap. Examine the

▼ *To provide maximum work space (which you will need), remove all shelves from cupboard under sink. For feed-tube work requiring solder, remove the drain connections between the sink bowls and U-trap.*

fittings and washers before replacement. You may find some parts badly corroded. This is the ideal time to replace such defective parts so that you can forget all about sink plumbing for a long time to come.

See also: DRAINS; PLUMBING.

Three Easy-to-build Fence Designs

Once you have determined exactly what your fence needs are, and checked your town's regulations regarding fence size, you can begin construction on these simple but beautiful fences

FENCES ARE erected on residential properties for safety, convenience or decorative reasons. Some of the main purposes are to prevent other people or their pets from encroaching on the property owner's private domain, to keep ones own children and pets confined, or both. If the fence is made higher than eye level, the added objective may be to ensure privacy by blocking the view of neighbors or of passersby on the street, or to help muffle street sounds.

To these time-honored convenience reasons also add: to protect a garden area, particularly a vegetable garden, from the ravages of children, dogs, rabbits and other domestic or wild trespassers; to provide a wind baffle to protect a terrace, patio or other outdoor living area from unwanted winds; or conversely, by strategic orientation of the fence in relation to the prevailing wind, to divert cooling breezes into the same types of outdoor living areas.

Safety considerations that dictate the erection of fences most often relate to the protection of childern, pets and plants. A fenced-in play area for very young children relieves a mother of minute-to-minute supervision because the tots are confined to a safe area and because they are safe from the harassment of wandering dogs. A fence around a vegetable patch not only protects the plants, but keeps small children from spray-contaminated crops. In many areas, fences around swimming pools are required by law; even if your local regulations do not prescribe such mandatory fencing, it should be added anyway to keep wandering children from falling into the pool and to keep the poolside area free of contamination by roaming animals.

Fences are sometimes erected even when there are no compelling safety or convenience considerations just to add decorative

touches to the property. A fence along the sidewalk or roadside can add dramatic impact to the home and law just as a picture frame can enhance a painting. Just be sure to choose a fence design having proper empathy with the basic styling of your home so that it adds to, rather than detracts from the overall effect. In the garden a short fence that actually encloses nothing may be used as a support for climbing roses or other plants, or to serve as a contrasting textural background for other plantings. The same or separate fences may also be used to hide such necessary eyesores as a wood pile, compost heap or garbage cans.

Before you erect any kind of fence, check your town ordinances for any regulations concerning the heights and types of fences that may legally be used in your residential area. Also make some effort to determine whether your intended fence will be accepted by neighbors as a contribution to neighborhood aesthetics, or at least be gracefully tolerated because it does not detract from the appearance of the neighborhood. In some residential areas fences are taken very much for granted. Where lots are small, and houses are close together, erecting a fence may be the only practical way to ensure mutual privacy. In an area where the lots are an acre or larger in size, the prevailing community desire may be to keep fence construction at a minimum to maintain an open and uncluttered atmosphere. But even in such an area there may be no neighborhood objections if you leave the front yard unfenced and limit enclosures to the side and rear yards.

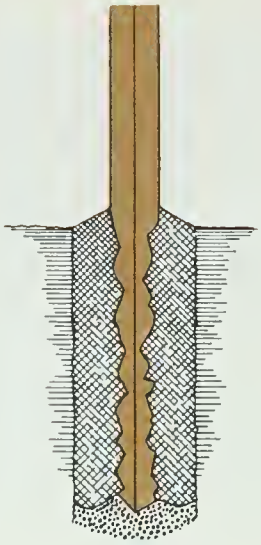
Above all, be very sure that your fence is of safe design. It must have no sharp components on which running children could fall or otherwise impale themselves, nor should it have projecting nails or other sharp hardware on which people might scratch themselves. In particular, avoid those precious little picket fences that are only a foot or so high; they keep nothing out or in, and they serve only to trip the unwary.

Attractive and highly functional fences may be made of many different kinds of materials including wood, metal, brick, poured or block concrete, stone or plastic. Wood is a favorite material because it is easy to cut and assemble, looks attractive if properly maintained, and is one of the least expensive fence materials. Three different general-purpose fence styles are discussed here. The construction costs can be as low as $20 per standard 5 x 8-foot unit if you do the work yourself.

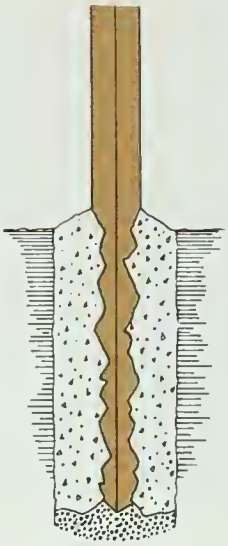
If neither the town nor your neighbors object to your fence plans, consider what type of fence design would be most appropriate for your purposes. Then decide what type of wood would be best and within your budget. Woods suitable for fencing include: Douglas fir, Engelmann spruce, Idaho white pine, lodgepole pine, cedar, sugar pine, ponderosa pine, Sitka spruce, western hemlock, western larch and white fir. All of these woods possess three desirable properties: durability, straightness and workability. Posts and framing should probably be of *standard* or *construction* grades. Usable board grades include *commons* if you want a knotty appearance, or *select* for clearer effects.

While you await delivery of the lumber, go over your property carefully to make certain that you really know where your property lines run. Anticipate any problems you may encounter, such as erecting posts where bedrock is close to the ground surface. If you have decided to cut down on materials costs by by-passing such rot-resistant post woods as heartwood of cedar, or other woods pressure treated with preservatives, shop around for wood preservative materials you can apply to the lower ends of the posts yourself. Your local lumber dealer can probably advise what type of wood preservative is most suitable for soil conditions in your area.

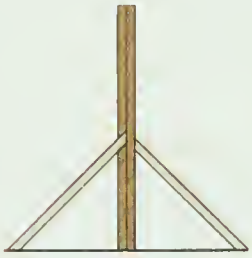
Post detail
Nail with 16d galvanized nails. (For contemporary screen fence 1 x 2 stock inside)



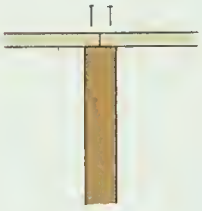
Packed dirt
Tamp dirt firmly around posts. At ground level, slope packed dirt away from post for drainage.



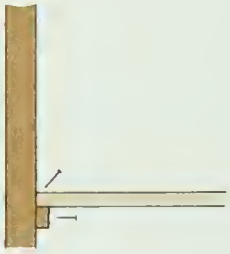
Poured concrete
Concrete may be used with preservatively pressure treated posts. Be certain to fill all space around post. Slope top away from post for drainage.



A simple brace will hold posts while pouring concrete or tamping.



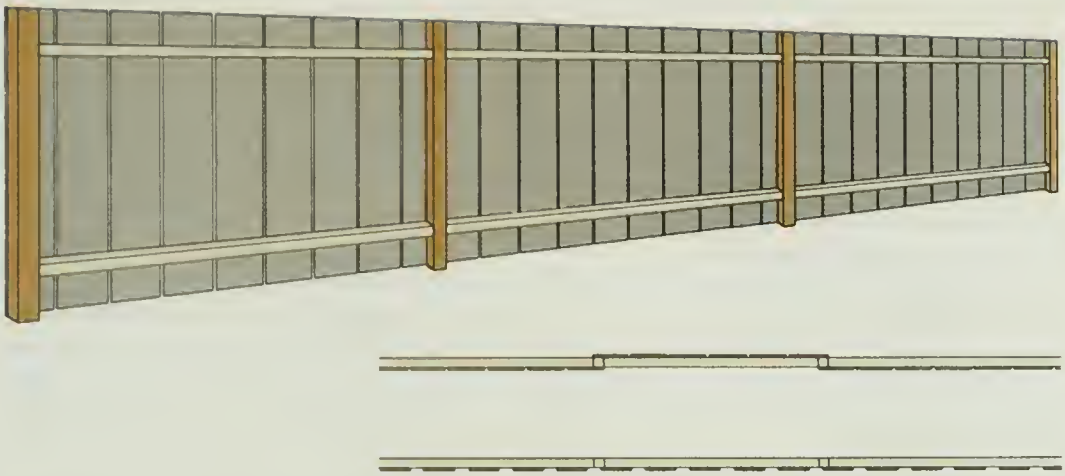
Top rail may be toenailed to post, or nailed directly to the top of the post.



Toenail with 8d nail; you may also use a 1 x 2 or 2 x 4 block for additional strength when appearance is not too important.

Top of posts are now cut off to a level line. Be sure to saturate the exposed end grain of the wood with a preservative after cutting.

Diagram shows variety of ways to sink and secure fence posts. If you plan to dig the holes and wait to sink the posts, be sure to cover the holes to avoid mishaps.



This board fence is probably the easiest of the three to build because the boarding is simply nailed to the top and bottom rails. You can add a dramatic affect by alternating the boards from one side to the other as shown in top diagram.

Use strong cord to lay out the fence line, locate the post holes (normally 4′ or 8′ apart), and dig the holes which should be about three feet deep. If the fence is to be higher than five feet, increase the underground section of each post proportionately to ensure stability. Buy or rent a post hole digger if there are many holes to be dug; the digger resembles two ordinary long-handled shovels joined face to face by means of a hinge. If the posts are not to be put into the holes immediately, cover the holes so that no one will be injured.

Drop the posts into the holes and use scrap wood braces to hold them erect and plumb. Use a carpenter's level to make sure they are plumb, and sight along the tops to see that the line of posts is straight. Do not worry if the tops are not all exactly the same distance above the ground (this could happen if a stone prevents planting a post as deep as the others). You can quickly top the longer poles with a hand saw after the boarding has been added.

The quickest and easiest way to set the poles is to tamp dirt into the spaces around the posts, using a metal or wood tamper. After you have pounded in all the dirt possible, add a little more to make a mound around the base of the post to shed rainwater away from the post. If the soil is structurally too loose to hold the posts firmly, fill the holes with poured concrete, making sure that all spaces are filled. It is best to use wood pressure treated with preservatives. Slope the concrete at the top to divert water from the post.

To further stabilize the posts, immediately add the top rails which may be toenailed between the posts, or in some cases nailed directly to the tops of the posts, depending on the type of fence to be made. In like manner, toenail the bottom rail to the posts using eight penny galvanized nails. These rails can be additionally supported by the addition of 1 x 2-inch or 2 x 4-inch block nailed to the posts, just under the rail ends.

Conventional solid, square posts measuring 4 x 4 inches are used for the board fence and for the horizontal siding fence to be discussed. The contemporary screen fence posts are made up of pairs of 2 x 4 components separated by three-foot lengths of 2 x 4 stock at the lower ends, to form slots into which the horizontal members can be added. To make the posts, nail the two outer members to the inner member using 16 penny galvanized nails.

Board fence. This traditionally styled

fence is the easiest of the three to build because the boarding is simply nailed to the top and bottom rails. If the fence is much over five feet high, it would be wise to add a third horizontal rail in the middle, between the top and bottom rails.

The surface boarding can be any width of one-inch thick board, spaced an inch apart. To make a standard height fence, use boards about five feet long. Note that you do not have to put all the boarding on the same side of the fence. For a bolder visual effect, alternate the boarding from one side of the fence to the other from one section to the next.

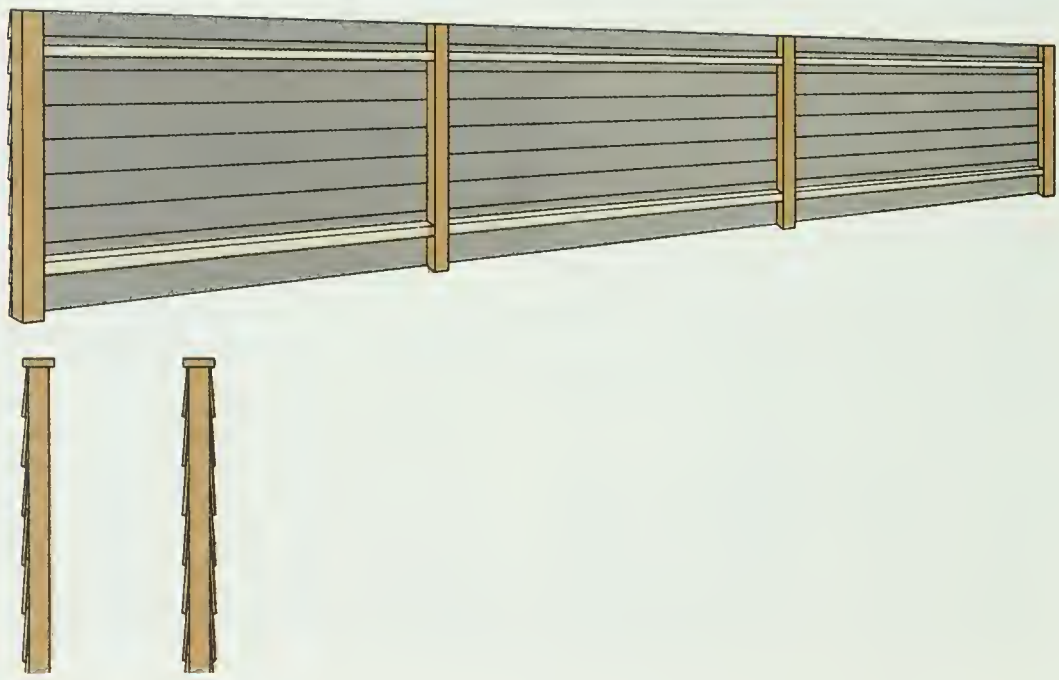
Horizontal siding fence. This type of fence is especially appropriate if your home is finished with siding. For example, if you use a ¾-inch beveled siding for the fence, to match the house siding, you can create a long, luxurious look that could be the envy of your neighborhood. This fence features an optional top cap made of 1 x 6-inch boarding. When installing the boarding, use a one inch overlap whether you use beveled or standard boards.

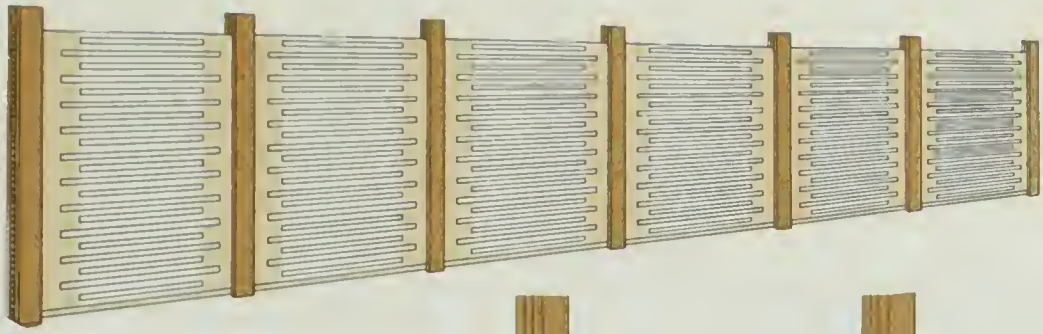
If the fence is to be a property divider, your neighbor may be interested in a joint project to make it a double-beveled fence which has the same finished look on both sides. This type of fence has many other applications, other than as a property line fence. It can serve as a connector between the garage and house, as an exterior space divider, or as a screen to hide garbage cans and the like.

Contemporary screen fence. The construction of the special fence posts needed for this fence has already been described. To make the horizontal strips rip 1⅝-inch wide strips from larger boards or buy the 1 x 2 inch stock from the lumber company. Treat these strips with preservative and paint before you assemble them, to make the job much easier.

Start assembly by nailing 8-foot bottom rails (2 x 2 inch) between the posts. Now stack the three different lengths of 1 x 2 inch

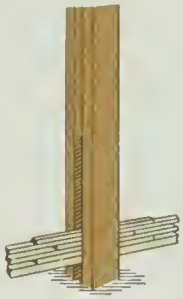
Horizontal siding fence is especially appropriate if your home is siding-finished. Bottom two drawings show fence side view with optional caps made of 1 x 6-inch boarding.





Use 1 x 2's or rip pieces 1⅜" wide from larger boards. Set posts four feet apart.
Preserve and stain 1 x 2 boards before installation—it will make your job much easier.
1 x 2's can be nailed as they are placed, then nailed occasionally to the 2 x 4 posts.

Start by nailing 2" x 2" between two post pieces



Next begin stacking and nailing the alternating boards and spacers.

stock in the proper sequences to form the indicated pattern. Note that the two different length shorter pieces of stock are used as fillers between the full length strips to create the alternating short and long open spaces.

Place an 8-foot length between the post pairs, atop the rail. Next insert a 15⅝-inch strip into each post slot so that it projects the same amount on both sides of the post. Now add another 8-foot length, then the shorter spacer (9⅝-inches long). The pattern is thus built up of the following sequence repeated a number of times: long, medium, long, short.

Note that there is no "front" or "back" to this fence since both sides have the same finished look.

There is only one way you could go wrong when building this fence, and that has to do with spacing the posts. If you are to use 8-foot lengths for the longest strips, without wasting lumber, the posts must be placed 8 feet apart *on center*. Otherwise the long strips will not reach from the center of one post to the center of the other. When making the two other types of fencing you

Spacing of posts is the trickiest part of building the contemporary screen fence, one of the more attractive wood designs. If you are using eight-foot lengths for the longest strips, you must place posts eight feet apart on center, otherwise strips will not reach.

One of the nicest features of the contemporary fence is there is no front and back. And being identical, both sides are attractive.

can similarly space the posts 8 feet apart on center, and cut a few inches off each rail. This might be safer than trying to make the space *between* each pair of posts exactly 8 feet to accept the stock length uncut.

One final tip: Maintain your fence by either painting or otherwise weatherproofing it periodically to preserve its beauty as long as possible.

See also: CONCRETE BLOCKS; DECKS; PATIO.

Build a Storage Area into Your Fence

This inexpensive, easy-to-build storage shed will remove garden tools and supplies from your garage floor and perhaps give you space for a second car or even a workshop

TIRED OF TRIPPING over the lawnmower, sweeper, leaf blower and the many other garden tools and supplies that you now have stored in the garage? It is now possible for you to clear the garage of all these vital but space-devouring objects and use the liberated space to house the second family car or perhaps to set up a fine workshop.

This inexpensive, easy-to-build five-module shed could be the answer to your storage problems. It can be constructed as an integral part of a structurally similar backyard fence, or you can just make the shed and forget about the fence. If you do not need a five-module size, or do not have enough yard space for it (approximately 3 x 15 feet), you can whittle it down to whatever size suits your needs best.

Each of the five modules meaures 3 x 3 feet and is a little under six feet high. They are strung side by side atop a "foundation" made of pressure treated wood. The horizontal boarding slats, which form the doors and rear wall, have open spaces between them to provide complete ventilation and to make the rear of the shed indistinguishable from the adjoining fencing. Your neighbor will like that feature because he will not even be able to see your utility shed. If such thorough ventilation does not seem important, you can of course alter the construction to create a fully closed structure.

You are also free to use the storage space as you see fit, but do study the designer's ideas about tool arrangement so that you will not overlook any worthwhile ideas. Note that the first unit on the left has a door at the end, rather than on the front as in the case of the four other modules. This end door makes it easier to run in a large piece of equipment such as a large power mower or a tractor; a drop-down ramp makes this operation even easier. The lower portion of the partition separating the first and second modules is eliminated so that there is more floor space for such large equipment.

The third section might be used to store a gardener's potting tools and supplies. You can quickly add shelves as needed by sliding boards of proper size into the spaces between the wall boards.

fertilizer: see lawns
fertilizer combinations: see fertilizers
fertilizer, natural: see organic gardening

Build a Storage Area into Your Fence

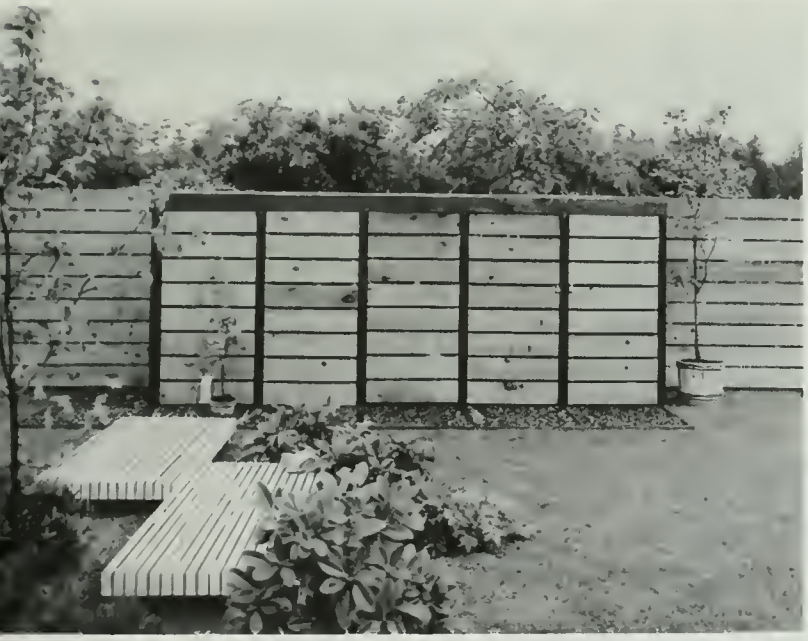
The fourth module is designed for vertical storage of such long tools as rakes, shovels and hoes. Support the tools with hooks or hangers designed to best handle the types of tools you own.

The fifth module provides space for such large items as a lawn sweeper, hose, or even stacks of extra brick or lengths of drain pipe. A lockable cabinet at the top of the module is used for storage of garden insecticides and other chemical sprays that should be kept from the reach of children. Also note that the doors in all modules are constructed so that they can be fitted with storage shelves—somewhat like those you have on the door of your refrigerator.

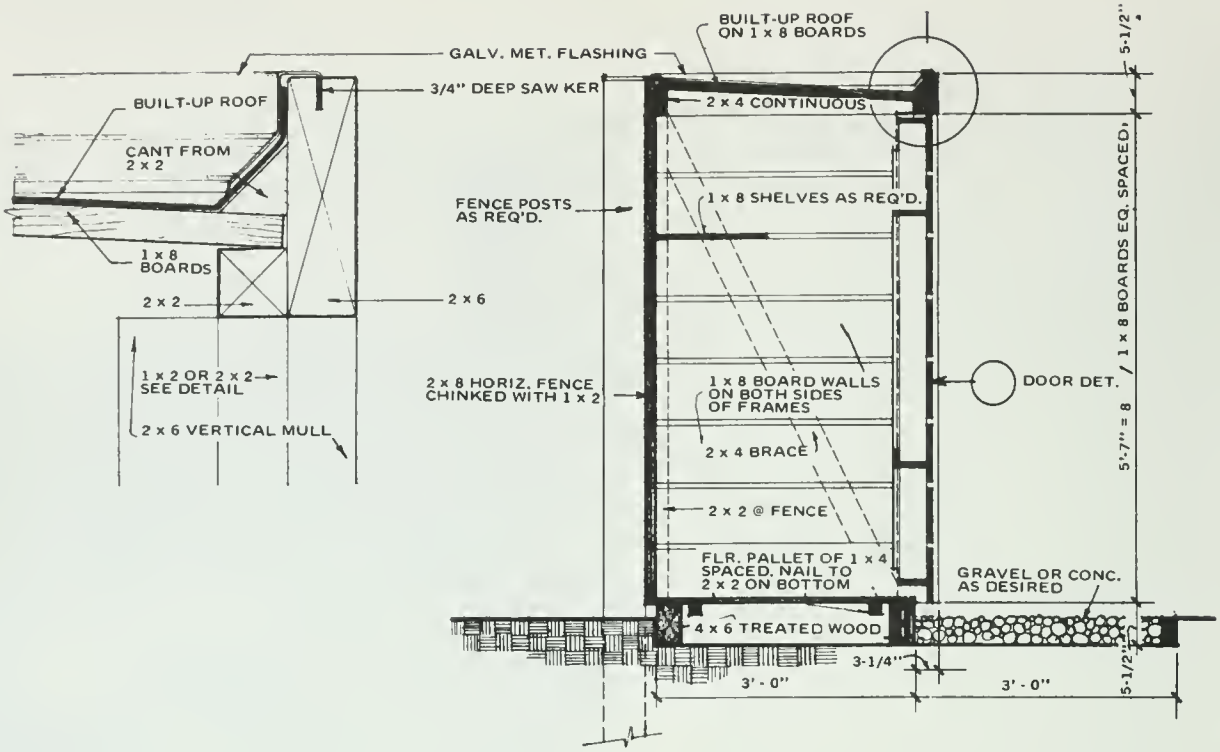
You can construct the shed from any type of wood that looks good and that you feel is priced right. Redwood or cedar would be ideal because these woods are especially weather, fungus and insect resistant. Other woods may also be used, but you should seal them with paint or varnish to protect against decay.

Build for durability. The section view in the drawing shows how to get started. The

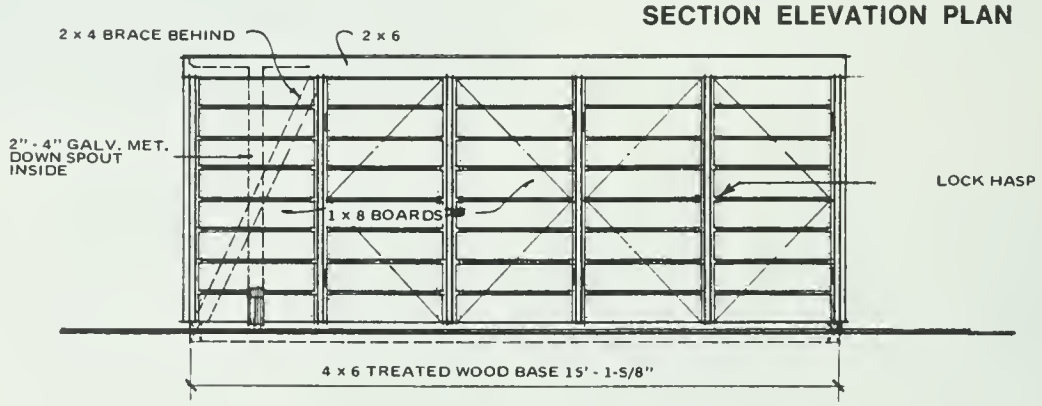
▲ *The five modules have been roughly planned by the designers, but you can use the storage space as your needs dictate.*

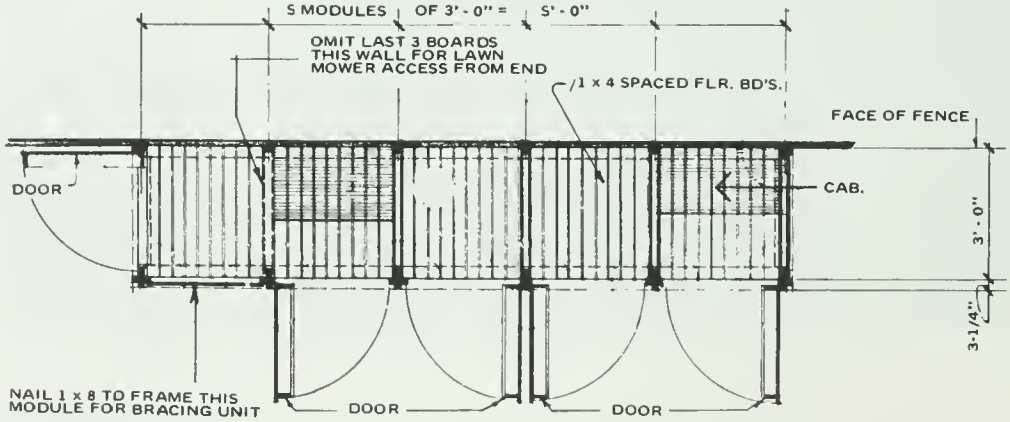


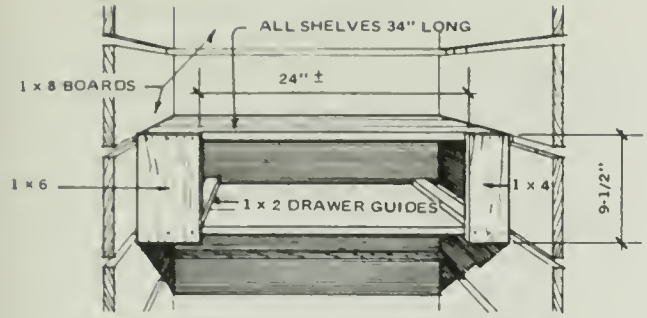
◀ *When closed, the shed blends into your backyard fence, and the decorations around its base are bound to enhance the beauty of the backyard. The slats shown in doors are designed for ventilation and easy installation of shelves and cupboards.*

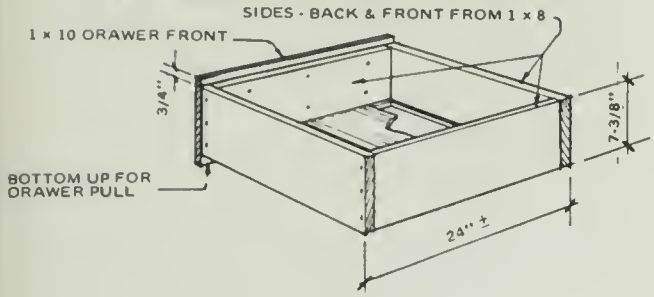

BUILT-UP ROOF ON 1 x 8 BOARDS
GALV. MET. FLASHING
3/4" DEEP SAW KER
BUILT-UP ROOF
CANT FROM 2 x 2
1 x 8 BOARDS
2 x 2
2 x 6
1 x 2 OR 2 x 2 SEE DETAIL
2 x 6 VERTICAL MULL
2 x 4 CONTINUOUS
FENCE POSTS AS REQ'D.
1 x 8 SHELVES AS REQ'D.
2 x 8 HORIZ. FENCE CHINKED WITH 1 x 2
1 x 8 BOARD WALLS ON BOTH SIDES OF FRAMES
DOOR DET.
2 x 4 BRACE
2 x 2 @ FENCE
FLR. PALLET OF 1 x 4 SPACED, NAIL TO 2 x 2 ON BOTTOM
GRAVEL OR CONC. AS DESIRED
4 x 6 TREATED WOOD
3-1/4"
3' - 0"
3' - 0"
5-1/2"
5'-7" = 8 / 1 x 8 BOARDS EQ. SPACED
5-1/2"

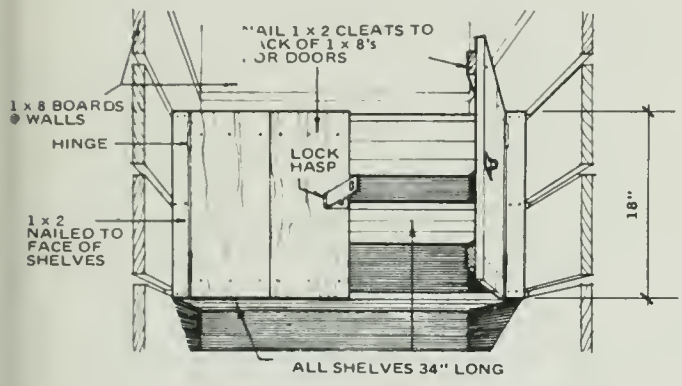
SECTION ELEVATION PLAN

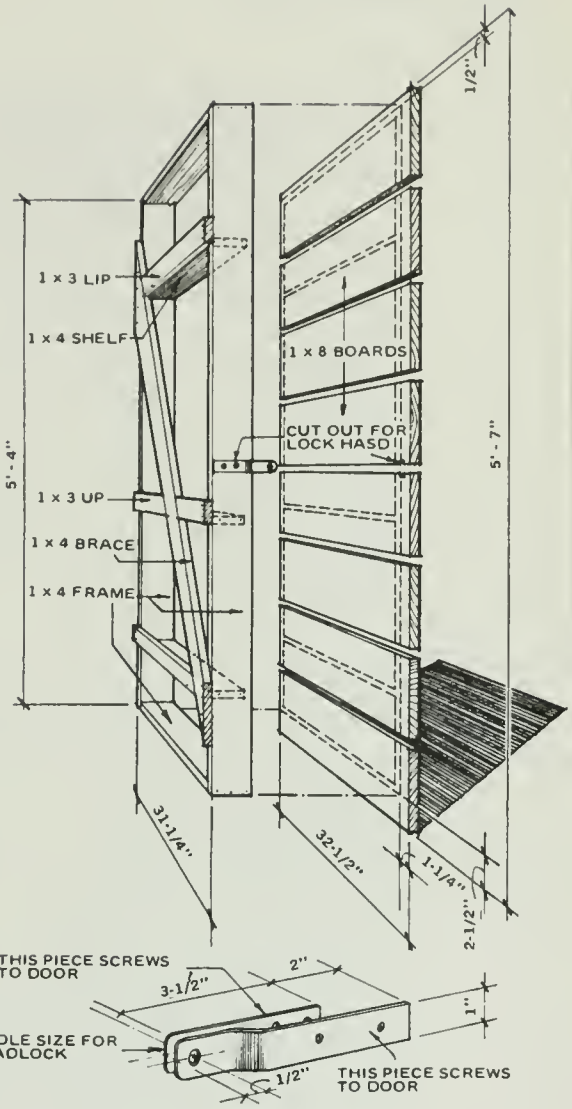



5 MODULES OF 3' - 0" = 5' - 0"
OMIT LAST 3 BOARDS THIS WALL FOR LAWN MOWER ACCESS FROM END
/1 x 4 SPACED FLR. BD'S.
FACE OF FENCE
DOOR
CAB.
3' - 0"
3-1/4"
NAIL 1 x 8 TO FRAME THIS MODULE FOR BRACING UNIT
DOOR
DOOR

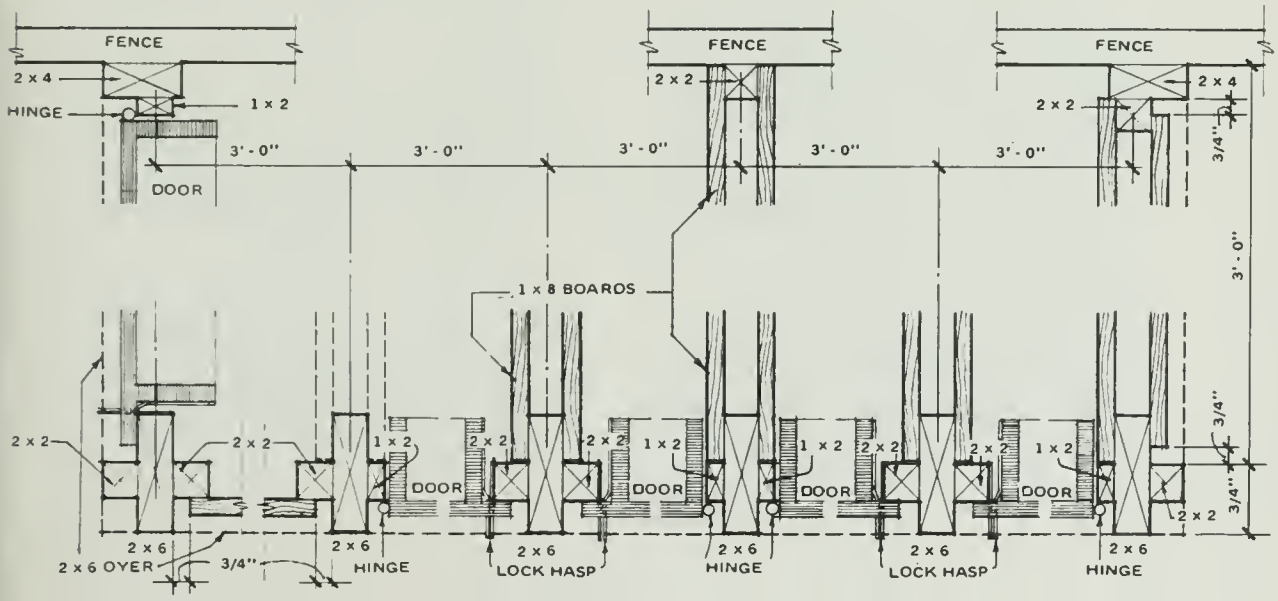

ALL SHELVES 34" LONG
1 x 8 BOARDS
24" ±
1 x 6
1 x 2 DRAWER GUIDES
1 x 4
9-1/2"


SIDES - BACK & FRONT FROM 1 x 8
1 x 10 ORAWER FRONT
3/4"
7-3/8"
BOTTOM UP FOR
DRAWER PULL
24" ±


1 x 8 BOARDS
WALLS
HINGE
LOCK
HASP
1 x 2
NAILED TO
FACE OF
SHELVES
18"
ALL SHELVES 34" LONG


1/2"
1 x 3 LIP
1 x 4 SHELF
1 x 8 BOARDS
CUT OUT FOR
LOCK HASP
5' - 4"
5' - 7"
1 x 3 UP
1 x 4 BRACE
1 x 4 FRAME
31-1/4"
32-1/2"
1-1/4"
2-1/2"

THIS PIECE SCREWS
TO DOOR
2"
3-1/2"
1"
HOLE SIZE FOR
PADLOCK
1/2"
THIS PIECE SCREWS
TO DOOR


FENCE
2 x 4
HINGE
1 x 2
DOOR
3' - 0"
FENCE
2 x 2
FENCE
2 x 2
2 x 4
3/4"
1 x 8 BOARDS
3' - 0"
2 x 2
2 x 2
1 x 2
DOOR
2 x 6
2 x 6 OVER
3/4"
2 x 6
HINGE
2 x 6
LOCK HASP
2 x 6
HINGE
2 x 6
LOCK HASP
2 x 6
HINGE
2 x 2
3/4"

shed is supported by two 15-foot "foundation" beams made of 4 x 6-inch planking. Be sure to use stock that has been pressure treated with a preservative because these members will be in contact with the soil. Better yet, lay the beams on a sub-foundation made of concrete block sunk unto the earth.

The floor pallet that lies atop the wood foundation is made of 1 x -inch boards nailed to 2 x 2-inch strips underneath. (Note: Here and throughout the following general description look for more specific information about actual parts dimensions and ways in which they are fitted together by referring to the drawings.)

The vertical supports along the rear wall are all 2 x 2-inch posts except at the corners. The left rear corner unit is made of a 2 x 4-inch and a 1 x 2-inch component; the right rear post has a 2 x 4-inch as well as a 2 x 2-inch member.

The walls are made of 1 x 8-inch boarding, with the boards spaced an inch apart. There is good reason to adhere to this spacing, as we shall see shortly.

The built-up roof, supported by 1 x 8 inch boarding, is pitched forward slightly. Note the galvanized metal flashing shown in the detail, and the connecting 2 x 4-inch galvanized metal downspout inside the shed, as shown in the *elevation* drawing.

To construct the doors, make the outer frame of 1 x 4-inch boarding, then add the shelves, lips and diagonal brace as shown. The framework is then boarded, on the outside, using 32½-inch lengths of 1 x 8-inch boarding.

The inner partitions separating the five modules are double walls made of boarding nailed to both sides of the front and rear 2 x 2-inch posts. Although it would seem that a single wall would suffice, you will find that adding shelves, cupboards and even drawers will be fast and easy if you provide the double-wall construction, making sure to space the boards a full inch apart. Of course, this obvious advantage is a mixed blessing; the free flow of air through the cracks is good, but moisture can also get inside during stormy weather when rain comes down at a wind-blown slant.

Shelves, cupboards and drawers. A good example of the wisdom of this open wall construction appears when it comes to adding shelves, cupboards and drawers. In this case the object is to provide a drawer to hold small tools. First make a wooden box having a top and bottom that project an inch beyond each side and rear wall of the box. The box walls are made just high enough so that these lips can be thrust into the cracks between the boards making up the rear wall and two inner partitions. Thus the box becomes self-supporting, without the use of nails or other hardware, and it may be moved to another location at any time. To complete the drawer assembly, add the two small front pieces and drawer guides to the box, then construct the drawer to fit. Note in the drawing that the front panel of the drawer is extended downward far enough to provide a lip for pulling it out.

To make a cupboard, construct a higher box. Once again the top and bottom panels are made large enough to lock into the wall spaces. To complete, add the inner shelf and doors.

What happens if you wish to locate a cupboard at the top of two adjacent modules? Obviously you cannot thrust the supporting lips of two cupboards into the same slot in the connecting partition. That is the reason why you should provide each module with two inner walls of its own—so that you can place drawers, cupboards, and shelves anywhere at any time.

Incidentally, adding a new shelf—now or later—is about as easy as any job could be. Just cut a board to the proper length and shove the two ends and the rear edge into spaces between the wall boards.

The final touch you should add to this re-

Build a Storage Area into Your Fence 1047

MATERIALS LIST

Quantity	Size and Description		Purpose
	1″	3″x40′ lumber of your choice	door shelf lip
	1″	4″x150′ lumber of your choice	door shelf and brace
	1″	8″x110′ lumber of your choice	door front
	1″	8″x360′ lumber of your choice	wall
	2″	6″x72′ lumber of your choice	mullion
	2″	2″x114′ lumber of your choice	mullion
	1″	2″x30′ lumber of your choice	mullion
	2″	4″x60′ lumber of your choice	braces
	2″	4″x12′ lumber of your choice	partition back
	1″	8″x72′ lumber of your choice	roof sheath
	2″	2″x16′ lumber of your choice	roof nailer
	2″	4″x16′ lumber of your choice	roof nailer
	2″	6″x39′ lumber of your choice	roof fascia
	1″	4″x141′ lumber of your choice	flooring
	2″	2″x30′ lumber of your choice	flooring nailer
	4″	6″x38′ pressure treated lumber	flooring base
	1″	8″x60′ lumber of your choice	interior storage unit shelves
	1″	8″x14′ lumber of your choice	interior storage unit drawer sides and bottom
	1″	10″x2′ lumber of your choice	interior storage unit drawer front
	1″	2″x4′ lumber of your choice	interior storage unit side glide
	1″	8″x6′ lumber of your choice	interior storage unit cabinet front
	1″	2″x9′ lumber of your choice	interior storage unit stile front
1	⅛″	1″x45″ galvanized steel	
	2″	4″x6′ galvanized metal downspout and leader	
10	3½″	butt hinges	main doors
4	2″	butt hinges	locked cabinet
	5″x36′ 28 GA. galvanized flashing		

NOTE: The above based on five units (without fence being used for back wall).

markably efficient storage shed is a concrete or gravel bed around the front and ends. Not only will this apron improve the overall appearance, but it will eliminate a lot of hardwork by keeping grass and weeds well away from the shed walls.

See also: DECKS; FENCES; GARDEN TOOL SHED; PATIOS.

Selecting the Right Fertilizer for Your Lawn and Plants

Knowing the important variables of fertilizer cost and effectiveness can save you money and your lawn

SOIL IN ITS NATURAL STATE is rarely fertile enough for optimum growth of plants. Usually it is necessary to supplement the earth's store of plant nutrients before you can obtain the most vigorous lawn, the most abundant flowers or the greatest yield of nutritious vegetables. The easiest way to furnish these added nutrients is through the application of mixed-fertilizers.

Garden-supply stores offer a wide variety of materials for fertilizing lawns and gardens. They vary in price as widely as they vary in specified uses, but the primary variables involved are the nutrient content (percentage of nitrogen, phosphoric oxide, and potash), ingredients—products containing slowly available forms of nitrogen cost more per pound than those containing quickly available forms—form, added materials and package size.

These various products all have their advantages and disadvantages, but only you can determine if it is worth the extra money for a certain product. These are some helpful hints on how to determine what your needs are.

Manufacturers of mixed fertilizers are required by law to state on the container the guaranteed content of primary nutrients. These primary nutrients are nitrogen, phosphoric oxide and potash.

The primary-nutrient content of a fertilizer mixture is indicated by its grade—a series of three numbers separated by dashes. The numbers show the percentages of each ingredient in the order listed above. For example, a mixture with the grade 5-10-5 contains five percent of total nitro-

fiberglass boat: see boat building projects
fiberglass ladders: see ladders
fiberglass panels: see panels
fifth wheel: see campers
files: see hand tools

gen, ten percent of available phosphoric oxide and five percent of soluble potash.

Because nitrogen, phosphorus and potassium are used by plants in large amounts, these nutrients are likely to be deficient in the soil. When you buy a fertilizer, therefore, you generally buy it for its content of these materials.

The relative proportions of primary nutrients in a fertilizer mixture determine the suitability of the mixture for specific soil and plants. Lawn fertilizers, for example, usually are highest in the proportion of nitrogen. Fertilizers for use on vegetables may be highest in the proportion of phosphoric oxide. It usually is wasteful, and may even be harmful, to use the wrong type of fertilizer. Follow recommendations closely.

Specialty fertilizers—manufactured in grades usually suitable for use on a specific kind of plant—are available for most garden applications. The specialty fertilizers include products for lawns, tomatoes and azaleas and other acid-soil plants. Usually they are satisfactory for use according to directions on their labels, but they usually cost more than ordinary farm fertilizers of the same grades.

Fertilizers of several grades may contain the same proportions of primary nutrients. For example, 5-10-5 and 6-12-6 are both composed of one part of nitrogen, two parts of phosphoric oxide, and one part of potash, though 6-12-6 contains the *higher* percentage of these nutrients.

Fertilizers having the same proportions of primary nutrients generally can be used interchangeably. It is usually only necessary to alter the rate of application so the desired amounts of primary nutrients are applied to the area being fertilized.

For greatest economy, buy fertilizer for its weight of nutrients, not for its total weight.

As for the ingredients, nitrogen is the most expensive component of a fertilizer mixture. Slowly available forms of nitrogen —urea-form and other organic sources— are more expensive than quickly available forms. Therefore, the more nitrogen a mixture contains—especially slowly available forms—the more expensive the mixture is.

Before plants can utilize nitrogen from a fertilizer mixture, the nitrogen-source material must be soluble. The more expensive forms of nitrogen must break down into soluble forms—nitrates, or in some cases, ammonia—before they can be used by plants. They break down slowly and release nitrogen to the plants over a long period of time. Less expensive forms of fertilizer nitrogen are already in available form; they can be used by plants immediately.

Fruits and vegetables properly fertilized with quickly available nitrogen are as healthful and tasty as those fertilized with slowly available forms. Because of their slow breakdown, however, urea-form and other organic sources of nitrogen may be more convenient to use than the quickly available forms. One application of the slow-release forms of nitrogen may nourish the plants throughout the growing season, whereas several applications of quickly available forms may be necessary.

Most ordinary farm fertilizers are granulated or pelleted materials. Fertilizer mixtures are also available in the powdered form, but the granulated fertilizers are more convenient for you to use.

Powdered fertilizers may be objectionable to use as they are too dusty, particularly on a windy day. They may become damp and may cake, failing to feed evenly through the fertilizer spreader. And they may stick to plant foliage, damaging the foliage.

Pelleted fertilizers are not as dusty and they do not cake as readily as powdered fertilizers. They flow easily through fertilizer spreaders, and they roll off the plant foliage, reducing danger of fertilizer burn. Farmers prefer this form.

Fertilizer concentrates, mixed with water, can be applied by garden hose through use of a relatively inexpensive mixing device. Being liquid, these fertilizers are readily available to plants; some nutrients are absorbed by the leaves of the plants. Because the materials are diluted considerably in application, there is little danger of damage to the foliage.

Fertilizer mixtures containing added materials—trace elements, insecticides or weed killers—are offered by many stores. These added materials usually cost more when bought as components of combination products than they do when bought separately

Trace elements (micronutrients) are essential to the growth of plants, but are needed only in very small amounts. Known micronutrients are iron, manganese, zinc copper, cobalt, molybdenum, sodium, boron, sulfur and chlorine. There may be others.

Do not apply these elements routinely. Plants need tiny amounts of these elements, but an overabundance of them may be toxic to the plants. Apply trace elements only if they are recommended by your county agricultural agent or your state agricultural experiment station.

Fertilizer-insecticide combinations and fertilizer-weed killer combinations are usually formulated for lawns. One problem with such combinations is that chemicals are being applied that would normally be used less frequently, or not at all. In some instances, fertilizers containing preemergence crabgrass herbicides are applied in the fall when, in fact, herbicide should be applied in the spring. Some fertilizer-herbicide combinations injure or kill trees or shrubs when applied to the grass beneath them. Pushing a fertilizer spreader back and forth under a tree or shrub often results in applying much more than the recommended amount of material.

Another problem is the concentration of the ingredients. There is no way of adjusting the rate of application for different uses.

Combination fertilizer and broadleaf weed herbicides are often applied when broadleaf weeds are not even present in the lawn. Also, there is a tendency to apply fertilizer with a broadleaf weed killer in the summer when cool-season grasses should not be fertilized.

Homeowners should be aware of these problems and take them into consideration when purchasing and applying fertilizer-insecticide combinations. Usually fertilizers and pesticides are best applied separately.

See also: GARDENING; HERBS; LAWN; ORGANIC GARDENING.

A wide variety of materials are offered for fertilizing lawns and gardens. It usually is wasteful, and may even be harmful, to use the wrong type of fertilizer. Make your selection carefully and follow the recommendations closely. Pelleted fertilizers are preferred by farmers since they do not cake as readily as powdered forms. They flow easily through fertilizer spreaders and roll off the plant foliage. Danger of fertilizer burn is reduced.

➤ *Changing oil filter requires a special wrench, but it is not expensive.*

How to Change Your Car's Filters

Get started as a weekend mechanic by servicing the devices that clean the air, fuel and oil in your car

SERVICING YOUR CAR'S FILTERS is an excellent beginner's job for anyone interested in becoming a weekend mechanic.

Filter service is simple—no complicated disassembly required.

It is also the most frequently needed service on a car. Oil filters are normally replaced three or four times a year, air filters once a year and gasoline filters once a year.

Name brand filters you can trust are available at discount prices (40 percent off list) in auto supply stores and the auto departments of discount houses.

The leading brands are: Purolator, AC, Fram and Wix. Stick to a name brand when buying filters. A poorly made filter is no bargain at any price.

Oil filter replacement. For this job you need a filter wrench (an inexpensive tool) and jacking capability.

Jacking capability is necessary to raise the front of the car several inches off the ground so you can get in underneath.

Although the oil filter may be accessible from the top of the engine compartment, the filter is replaced as part of an oil change. The engine oil drain plug is underneath and you've got to get underneath to remove it.

The car's bumper jack will raise the car, but it is hardly safe enough. The car should be supported on safety stands.

If the car's bumper jack is so inadequate that it will not raise the car high enough to slip the safety stands under the front suspension's lower control arms, then you need a better jack (there is no bumper jack worth talking about anyway, so you really should have something better).

An inexpensive choice is a scissors jack. This can be slipped under the front crossmember and will raise the frame (and carry the suspension with it) high enough to get the safety stands in position.

For two to three times the price of a scissors jack you can get a trolley jack, which is similar to the scissors jack but has a tricyclic stand, making it very easy to position and safer to use.

The easiest to use jacks are the hydraulic types. The inexpensive hydraulic jacks (about the price of a scissors jack) have very limited use, because they cannot get under most parts in the car's underbody (typical jack of this type is nine inches high when shaft is down to bottom).

filters, photographic: see photography
filters, pool: see swimming pool
finishes, natural wood: see painting, house
finishing: see furniture, indoor
finishing, floor: see floors

The best choice is the hydraulic floor jack, which is the type you see in most professional shops. It can get under anything, and it is very easy to use. It was once far too expensive for the weekend mechanic, but imported units are now available at moderate prices. The 1½-ton unit is all you need for even a full-size car, and a 1- or 1¼-ton is adequate for American compacts.

Still another option is the ramp. A pair of ramps, which the car is driven onto, will raise the car a foot to a foot and a half, depending on the model purchased. Ramps are relatively inexpensive; so shop around for quality, looking for such features as non-skid designs.

Ramps have the advantage of requiring no additional support. Even with a quality hydraulic floor jack, the car must be supported with safety stands.

You will also need a drain pan (which you can make out of a flattish container of at least one-gallon capacity; or you can use an inexpensive plastic wash basin). The drain pan must be large enough to hold the oil you will drain from the engine and most engines have a five-quart capacity. However, only four quarts at most will come out when you pull the drain plug.

With the car safely raised, remove the drain plug and allow the engine oil to drain out. For best results, the oil should be hot (it takes a fifteen to twenty mile drive to heat up the oil).

After the oil has finished pouring out of the drain hole, the oil filter can be removed. The wrench, as illustrated, wraps around the filter body and you just apply counterclockwise pressure.

Before installing the new filter, lubricate the filter's rubber gasket with clean engine oil.

Hand tighten the filter—do not use the wrench.

Cartridge filters. Some foreign cars have replaceable cartridge filters (American cars dropped this design many years ago in favor of the easy-to-install and replace spin-on unit).

With the replaceable catridge type, you must clean the container to remove sludge. Use a general purpose automobile solvent (such as the type used to clean carburetors).

The through-bolt that holds the container has one or more sealing O-rings on it, and these should be checked for a tight fit, and replaced at least every fourth oil change.

The filter container seals against a rubber gasket, which should be replaced every time the element is changed.

Air filter replacement. On most cars, there is nothing simpler than replacing an air filter element. A wing nut holds the filter cover; just remove it, pull out the old element and install the new. Some cars have spring clips to hold the cover, but that doesn't really make things any more difficult.

On some cars, however, the filter is cleaned, not replaced. Most Volkswagens have oil bath, wire mesh air cleaners, and many GM products have polyurethane foam filters.

Servicing oil bath. Remove the entire air filter assembly. Undo the wing nut that holds the wire mesh and remove it.

Inside you will see the oil reservoir. Dump out the old oil, clean the reservoir with solvent and refill to the level mark with clean engine oil. Dunk the wire mesh assembly in solvent, agitate, remove, and allow to air dry.

Refit the reservoir assembly, then bolt the wire mesh assembly to it.

Servicing polyurethane foam. Gently remove the foam from its metal cage, soak in solvent and gently squeeze dry (do not wring). Allow to air dry and dunk in clean engine oil. Gently squeeze out the excess oil and refit to the cage.

Replacing gasoline filter. There are three popular gasoline filters used in recent years: one is an element type on the fuel pump;

a second is in the carburetor fuel inlet boss; and the third (and most popular) is in the fuel line between pump and carburetor.

The fuel pump type is replaced by simply unscrewing the cover, lifting out the element, installing a new one and refitting the cover.

The type in the carburetor fuel inlet boss requires undoing the fuel line fitting. Pull the fuel line out of the carburetor inlet boss and inside you'll find the tiny element, made of sintered bronze or pleated paper. You will also find a filter positioning spring.

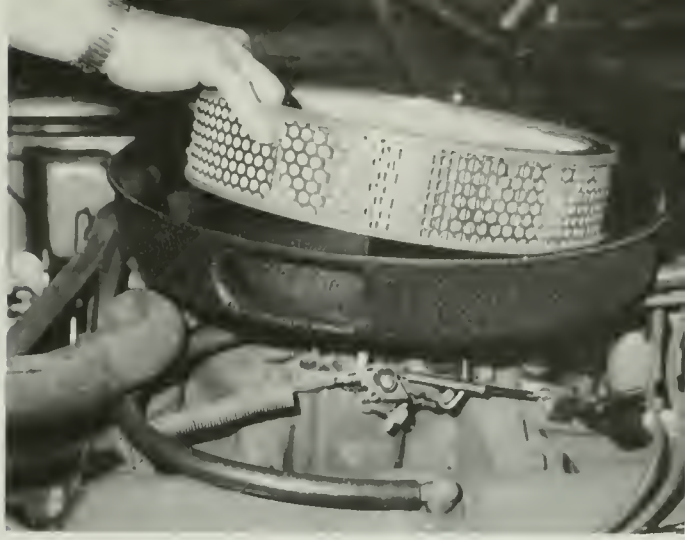
This type of filter is best discarded completely. If it is sintered bronze, it has poor filtering ability and will pass dirt particles 10 times larger than a good paper filter. If it is paper, it's so small it will clog in only a few thousand miles and the constant replacement is a nuisance.

The discarding of the carburetor boss filter doesn't mean you have to leave your fuel system unprotected. You can install an in-the-line gasoline filter, which will last a year because it is so much larger. Many cars are factory equipped with this type, but it does cost more than the smaller one, and Detroit has its penny-pinchers.

In-line gasoline filters. This type of filter is available in kit form, for installation on cars with no fuel filtration or with the inadequate carburetor boss type.

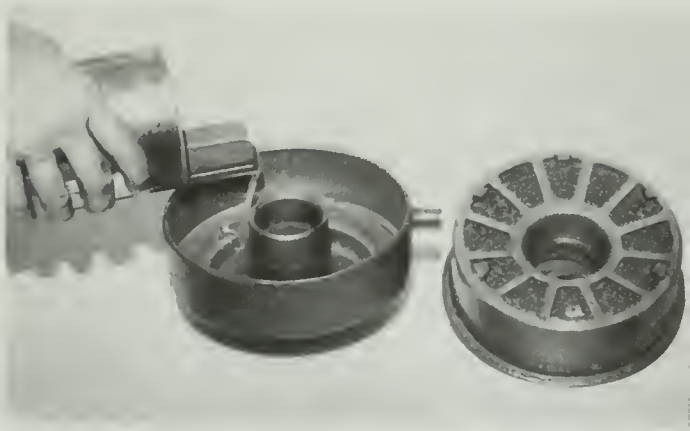
The kit differs from the replacement filter only in the inclusion of two short hoses. The boxes for both contain four spring clamps.

To replace the filter on a car so equipped, remove the clamps. The original equipment clamps are a pry-off type that you discard. Pull the hoses from the filter necks, and discard the filter.



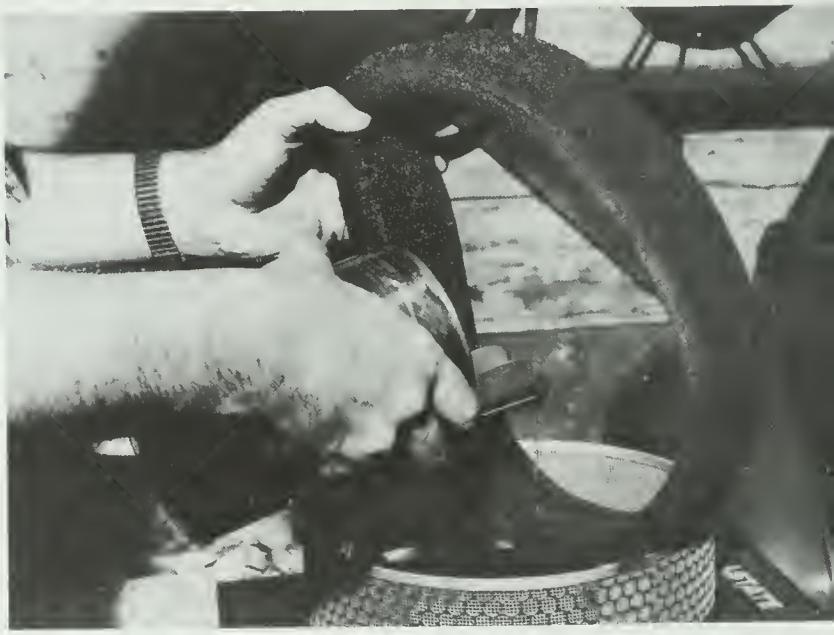
▲ *Replacing most air filters is simple. Take off the cover, lift it out and put in a new element.*

▲ *To service oil bath air cleaner, remove cover, which contains wire mesh. Clean wire mesh in solvent and allow it to air dry.*



➤ *Fill oil bath reservoir to the mark with clean engine oil.*

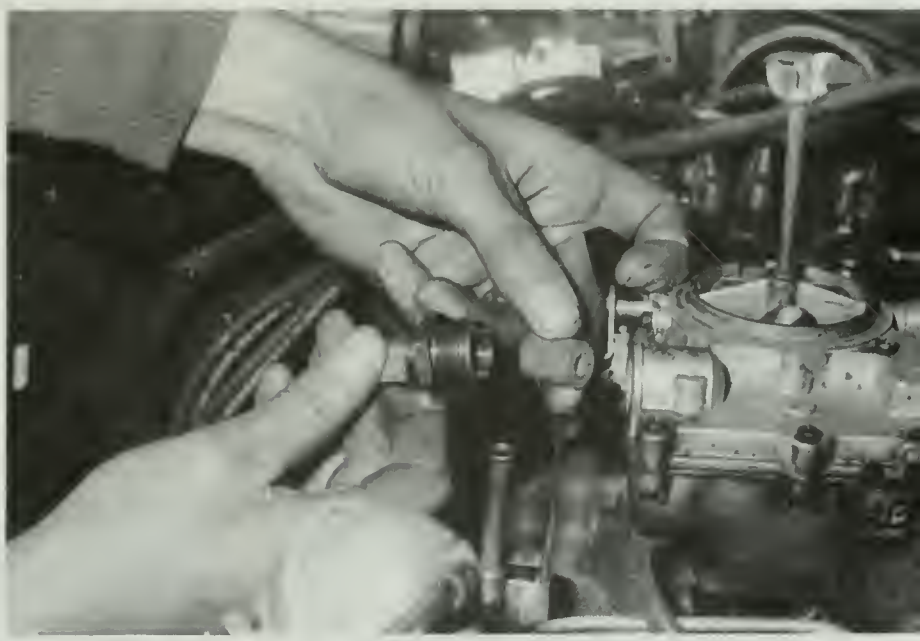
➢*Polyurethane foam filter is removed from cage for service. Dunk it in carburetor solvent, agitate and gently squeeze. Allow to air dry.*



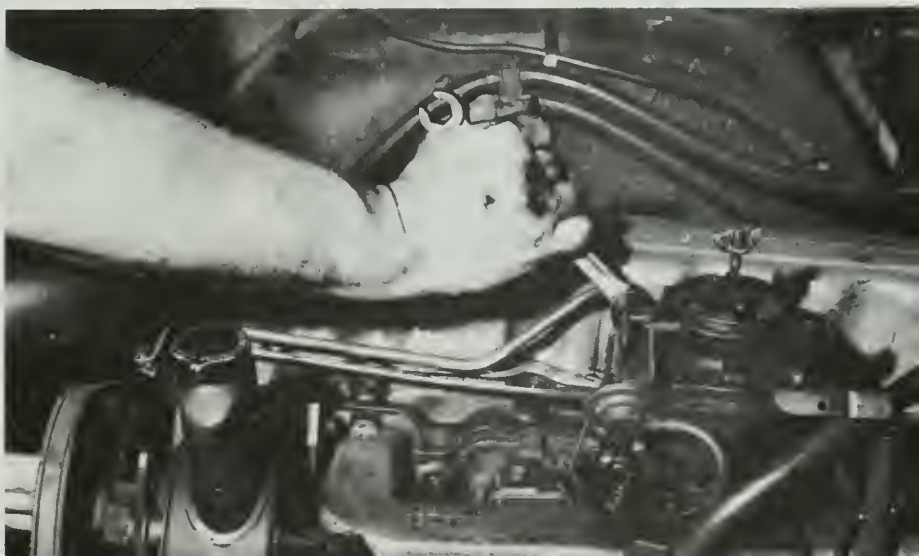
➢*Oil polyurethane foam with clean engine oil.*

➢*Squeeze out excess oil (gently) from polyurethane foam element and refit to cage.*

➤ *Pump-type gas filter is replaced by removing cover, taking out old element and installing new one.*

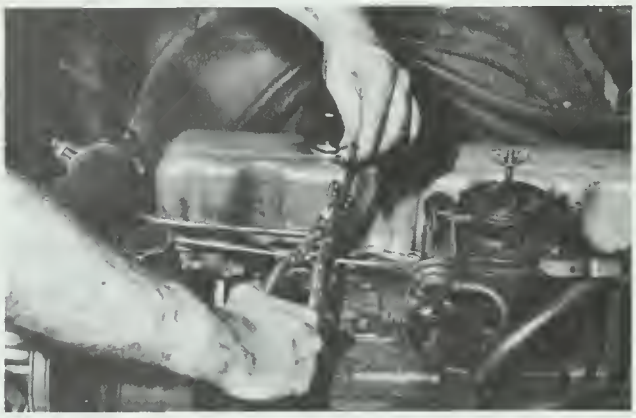


➤ *This is a sintered bronze filter in carburetor boss, accessible after removing fuel line (on some cars, filter is accessible after removing plug in carb side).*



➤ *Installing in-line gasoline filter begins with disconnection of fuel line at carburetor.*

Fit a spring clamp onto each hose. This can be done by spreading the tangs of the clamps with a pair of ordinary pliers, but it isn't easy. By filing a notch in the center of the top edge of each jaw, you will be able to hold the tangs for easy spreading. Or you can purchase a pair of hose clamp pliers, which are designed for the purpose. Such pliers are available in combination forms with tubing cutters, and if you are planning to install a kit, they are a worthwhile purchase.



Then cut out six-inch section of fuel line with tube cutter. Type used in illustration is combination tube cutter and hose clamp pliers.

Then install the filter, making sure that the arrow on the side of the filter container points toward the carburetor.

With the hoses firmly in place spread the tangs of the clamps and move the clamps to positions on the hoses over the filter necks.

Installing the kit. The kit takes about 15 minutes to install and requires a tubing cutter, such as the type that is built into some hose clamp pliers.

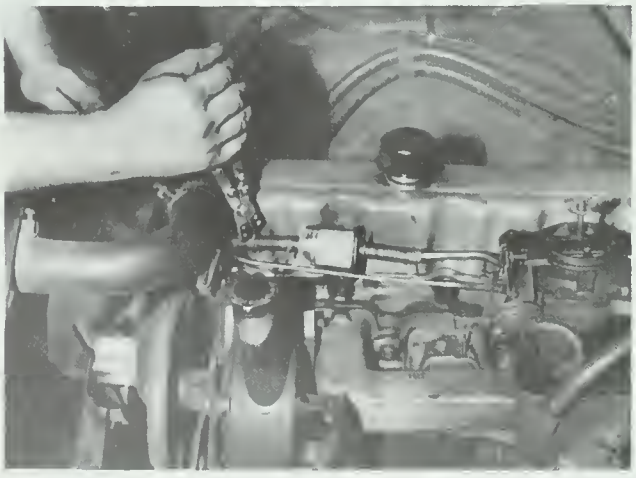
Find a six-inch section of fuel line between pump and carburetor that is reasonably straight and accessible, and with the tubing cutter, chop it out. You may find it easier to brace the fuel line by disconnecting it at the carb and holding it.

Fit a short hose on to the necks of the filter and secure with a spring clamp.

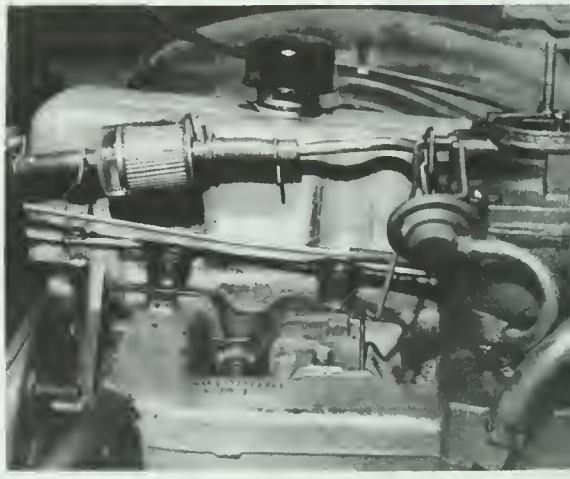
Position the entire assembly in the gap in the fuel line and secure with the remaining clamps. (Slip the clamps onto the line before you put the hose on; that's the easy way.)

After you have changed oil and a few filters, you will begin to feel more comfortable about working on a car, and can tackle other jobs. P.W.

See also: AIR CLEANERS; ENGINE.



Fit short hoses and secure with spring clamps furnished with kit.



The finished job. Run engine and check for leaks.

Stocking Your Refinisher's Cabinet

A minimum investment provides you with nearly everything you need to refinish furniture at home

FURNITURE REFINISHING is neither as difficult nor as involved as some experts would have you think. A minimum investment can let you do it at home where you can save money. Refinishing can even become a pleasant pastime. It's easy enough if you know the tricks, and the tricks are in the materials you buy for your refinisher's cabinet.

You don't need a vast array of equipment but you will need special solutions to remove old finishes, bleaches to lighten stains and water marks, materials such as shellac and varnish and perhaps a few stains. None of the items is expensive or difficult to find, and a professional refinishing cabinet can be assembled at a reasonable cost.

Removers and bleaches. The first step in any refinishing is the removal of the old finish. Wood alcohol is a basic ingredient here. If you're refinishing antique furniture it's a must. It is used to remove old shellac and for thinning new shellac you'll apply as either a primer or a finish coat.

Varnish finishes are relatively new and chances are that furniture more than 30 or 40 years old is finished with shellac. The old shellac is easily removed with wood alcohol; a quart will handle an average chair.

Pour about a cup of alcohol into a shallow bowl. Dip a small pad of medium-grade steel wool into the bowl and liberally soak a small area. Let the alcohol penetrate for a few seconds, then rub the area with the steel wool pad. Alcohol evaporates quickly and, if you wait too long between dousing and rubbing, the shellac can become gummy instead of soft. If this happens, don't try to rub the gum from the wood; add more alcohol and wait less time.

If you work small areas, rubbing fast

firearms: see reloading
fire detection: see home security sensors

with light, gentle strokes, the old finish will strip off easily. If some areas seem stubborn or the alcohol evaporates too quickly, try adding a small amount of lacquer thinner to the alcohol.

Paint removers are designed to remove hardened paint and work nicely on both painted and varnished surfaces, if the coats are not too thick. A quality paint remover is essential on varnished wood, since neither alcohol nor turpentine will soften the hardened finish. Nothing but paint remover will work with complete safety on painted areas.

When using any remover, be sure to follow the manufacturer's directions. Use the remover in light coatings. Thick layers of paint are best removed in two or three passes.

You'll find that most paint removers leave wax in the wood pores. This should be removed before repainting or shellacking, and the job can be done by scrubbing the wood with steel wool dipped in turpentine.

A paint scraper is a handy refinishing tool. It helps peel stubborn paints and lifts loosened surfaces off the wood. Generally you can use a scraper without danger to the surface, but once in a while paint is stubborn enough to require real scraping. Unless you're careful, the scraper will leave indentations and the only answer is re-sanding. When you re-sand you'll have to start the refinishing with a primer coat. If you plan to varnish, be sure to prime with two or three coats of thinned shellac.

Lye is a handy refinishing chemical. It's both risky and easy to use, a paradox which lies in the fact that lye is strong enough to remove three to five thick layers of paint in a single pass. Its very strength makes it capable of damaging wood, but if you use it properly, it can be as safe as any commercial remover.

Mix a can of lye with two quarts of water. Don't make the solution weak, hoping to reduce the danger. Lye doesn't work that way. A weakened solution will require more time to loosen the paint, and in the process of working may soak through to the wood.

But when the paint is thick nothing else works as well, and you can be fairly sure that a lye solution will do the job. Apply the solution with a rag wrapped around a stick. Use rubber gloves and work outside.

Literally soak the surface with lye. In five to seven minutes, the paint should be thoroughly loosened. Remove as much as you can with a scraper, washing the surface often with water. Stubborn areas can be cleaned with a wire brush. If you use a garden hose to rinse, you may find the water pressure alone will peel off much of the paint.

After the paint is removed, rinse the wood thoroughly and dry with a clean rag. Paint the area with vinegar, a mild acid that neutralizes the caustic lye. You can apply the vinegar with a brush. Apply one coat, let it dry, then apply a second coat of vinegar for protection.

Because lye almost always darkens wood, you may want to bleach to lighten its tone. A chlorine bleach such as Purex or Clorox

▲ *Alcohol will cut shellac, the finish used on most antiques. Pour small amount into bowl, apply, then rub off with steel wool.*

works well. Rub the wood with a rag saturated with bleach, and as fast as you apply the bleach, you'll find the color changes.

If small traces of the old finish seem to stand in the wood pores, scrub the surface with a medium steel wool pad dipped in bleach. The scrubbing will help lift the trapped finish and the bleach will do an even job. It isn't necessary to rinse a chlorine bleach. When it dries all traces are gone.

Oxalic acid is a mildly acid solution that's handy for bleaching water marks—the black spots so often found on table tops. Mix two ounces of oxalic crystals in a quart of water. Apply nearly boiling with a brush.

These bleaches will handle most of the jobs you'll run into. Just remember this rule: oxalic acid for the darker water marks, chlorine for all other stains.

In a few instances, you may want to lighten the natural color of woods such as walnut and mahogany. Neither oxalic nor chlorine bleach will work, and you'll need the rougher professional hydrochloric acid bleaches. These are dangerous solutions, so buy only enough for one job. Don't store the acid in your shop.

Hydrochloric acids are available under several trade names and generally come in two-bottle solutions. One bottle contains the bleach, the other the neutralizer. Follow the manufacturer's recommendations to the letter.

Equipment. Furniture refinishing requires few tools and a small investment will buy everything you need. Steel wool is a must. It's used in both the removal and refinishing stages. Use it in medium and medium-fine grades to remove old paint and in finer grades to rub out and polish new finishes.

You'll get your best value when you buy a full package. Separate a small ball of wool from the pack and shape it into a pad. Don't try to economize by carrying partly used pads from one step to another. You'll get better results by using a fresh pad for each step.

Sandpaper is another must. Again, don't try to economize. Cheaper papers are coated with flint abrasives. Flint is excellent for roughing-in jobs, but it's not suited for

▲ *To remove paint, liquid paint removers work best. Brush it over the painted surface and allow time for it to soak into the paint.*

▲ *In a short time, paint will wrinkle and lift from the wood. When the surface looks like this, paint is ready to be scraped away.*

fine furniture. Use the orange-colored garnet papers. These are well worth the difference in price. They cut faster than flint and leave a smoother surface, the only secret of a professional-looking final finish.

Paint scrapers are important. They're handy for removing old paints and varnishes and can be used to smooth slightly roughened surfaces.

A cabinet scraper is a small hand-held blade designed for one job: smoothing roughened and uneven areas before sanding. Although experts sometimes make do with a paint scraper, a cabinet blade is the ideal tool for a smooth job. Never try to sand uneven surfaces level and smooth with abrasive paper. A scraper is the solution and a few minutes with one can make sanding faster and easier.

Paint, varnish and shellac. When the old finish is off and the surface smoothed, the next step is the application of a new finish. The kind of new finish you carry in your shop depends, obviously, on the kind of new finish you prefer. If you like paint then a selection of paints, toning colors and brushes is all you need, but since we are dealing with furniture, the beauty of natural wood grains is generally more important and more desirable than the color accents of paint.

Shellac is a must. It is used as the final finish on many pieces of furniture and as a primer coat when you varnish. While it is available in both clear and orange tones, you'll find the clear is the best choice. The orange shellac is just too heavily toned for most woods, although you may find you like the warmer tone that's possible by mixing a small amount of orange shellac with the clear.

Mix the shellac with wood alcohol before applying. If you like the antique-looking hand-rubbed surfaces, try mixing shellac with 4 or 5 parts alcohol and rubbing the preparation into the wood. If you prefer to apply shellac with a brush, mix it with 2 or 3 parts alcohol. Either way, apply several coats.

Tables and counters need a heavier, more protective surface such as varnish. Be sure to use a clear synthetic; it dries faster, has a harder surface and has less effect on wood grains.

For a hand-rubbed appearance, try adding a final coat of dull varnish over one or two coats of clear. Let the varnish dry thoroughly, then rub lightly with 00000 steel wool and wax.

Turpentine is another refinishing staple. It is used as a thinner for varnish and for some clean-up work. Most experts prefer the less expensive turpentine substitutes: these mix as well as real turpentine and cost about half the price.

When thinning varnish, use turpentine sparingly. A good trick is to warm the varnish to make it flow. You'll find warmed varnish brushes better and dries faster than most thinned versions.

Stains are seldom needed in refinishing, but when you need to change the appear- of wood, nothing else does the trick. Most wood workers over-do staining, and the result is an unattractive blob in place of what could have been beautiful grain. Avoid the commercial stains which contain pigments. These hide, rather than uncover, grain patterns. Instead, try penetrating oil stains. Simply spread them on the wood, let stand for a few minutes, then wipe off.

Aniline dyes are available in water-soluble and alcohol-soluble mixes. A one ounce package of either will handle several pieces of furniture. You'll find alcohol-soluble dyes are most versatile because they can be used alone or to color shellac and lacquer. The colored shellacs and lacquers seem to stain the wood without actually interfering with the grain.

Brushes are a must, and while most workers spend startling sums buying the best available, you'll find cheaper brushes are actually better. You can use them once,

then throw them away. The result will be a better job, and if you've mixed your varnishes and shellacs properly, there's no more danger of brush marks with an inexpensive brush than with an expensive one.

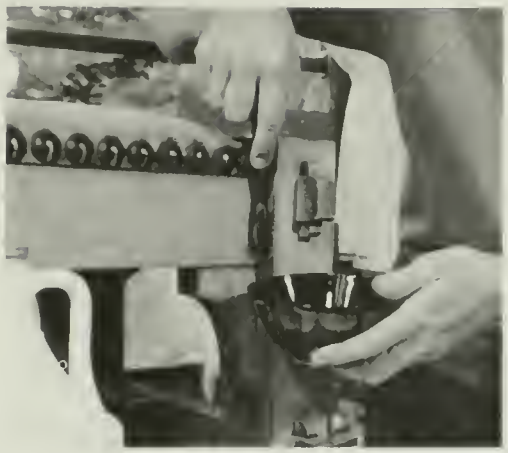
Incidental supplies. Boiled linseed oil is often used as a final finish in place of either shellac or varnish, but you'll find that a true linseed oil finish collects dirt, becomes grimy and dull and is generally uninteresting long before the job is done. A true, old-fashioned linseed oil finish takes about 10 coats of oil and a year's time and is not worth the cost of the oil or the time.

It is better to apply linseed over 2 or 3 coats of thinned shellac. The result is a warm, soft glow which looks like the real thing and never collects dirt.

Purists insist that the final rub-down be done with pumice and rottenstone. There's nothing wrong with these techniques. They work and the result is a soft, glowing patina that has the life and look of real furniture. The only trouble is that pumice and rottenstone take time. They must be mixed with water to form a paste, then rubbed until your arms nearly fall off. Most experts have found that a final rubbing with a super-fine steel wool—00000 or 000000—gives the same finish with less effort. Few, if any, experts can tell the difference.

Wood fillers are handy for any refinishing kit. There are many types available and most work nicely. The wood plastics are easy to use, although they will not take a stain once they have dried. A few firms offer pre-colored wood plastics (although the colors seldom exactly match the piece you are working on), but most must be colored at home. The plastics can be stained before they are applied by adding commercial stains a drop at a time until the dough is tinted to match the wood. When the plastic dries, it can then be smoothed for final finish.

These are the only items you'll need to do professional furniture refinishing at home.



To bleach wood, pour small amount of chlorine bleach into bowl, brush or wipe on. Wood will lighten as bleach contacts surface.

You will need a range of good abrasive papers plus a selection of steel wool. If you wish, you can include pumice, rottenstone.

The materials are neither costly nor bulky, and the best part is you can start your refinishing cabinet with little more than wood alcohol, paint remover and steel wool. It's easy enough to add the other items when you need them. Chances are once you try furniture refinishing, you'll have a full refinisher's cabinet before a month is over—refinishing is that easy and the results are that pleasing. B.B.

See also: ABRASIVES; ANTIQUING; FURNITURE, USED.

How to Prepare Wood for Finishing

Thorough preparation is the only assurance of perfect results. So avoid short cuts when the finish really counts

THOROUGH SANDING and preparation are the secrets of a professional, perfect finish, but most of us like to take advantage of short cuts when we can. Quick machine sanding and easy touch-ups by hand can deliver an acceptable finish for most projects, but when perfection is important, forget the short cuts.

Perhaps you've already learn that a fine finish is the result of meticulous care. If you haven't, then try this system when a project really counts. You'll be pleasantly surprised at the way it unlocks a new range of tones and patina in the wood.

Preparing wood for staining or varnishing takes time. It takes hard work. It requires hand work. Belt sanders—so handy for most jobs—are out. Orbital and straight-line sanders can be used for part of the job, but the preliminary and final stages must be done slowly by hand.

Preparing for sanding. No wood, not even the most expensive milled stock, is ready for sanding as it comes from the lumber yard. The rougher the stock, the more preparation needed before you can sand. When wood is extremely rough, as many hardwoods are, you'll have to plane the surfaces first.

If the stock is narrow, or if your machinery is big enough, the preliminary smoothing can be done on a jointer or planer. But if you lack these refinements, the work can be done with a hand plane. Work the surface end to end until it is level and smooth. In most cases, you'll do this before you begin building your project.

Most woods must still be smoothed before they are ready for sanding. The job can be done before the piece is assembled, or after the project is built. The choice depends on the job. If the material will be difficult to work after the job is put together, smooth the surfaces beforehand. The smoothing should be done with a cabinet scraper, the proper tool for the job and a more important tool than many people realize.

Don't underestimate the importance of a scraper. The amount of care spent scraping a piece of wood has a lot to do with the results you get from sanding.

Some people feel a scraper should remove only fine dust. It should do much more. If you've sharpened the blade properly—instructions come with the blades—the scraper works like a very fine plane, cutting off fine shavings as it surfaces and smoothes the wood.

You can work the blade on either a push or pull stroke, but it's best to work only one way. When the blade is pushed, hold it firmly with both hands, fingers on one side, thumbs on the other. Tilt the blade away from your body to avoid blade chatter as you work. If you work on the pull stroke, tilt the blade toward you.

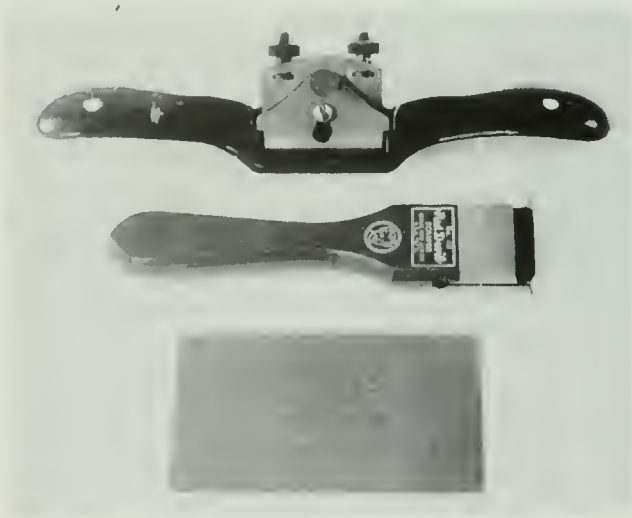
Some scrapers are designed to work in holders, like miniature planes. Others are simply metal blades, hand held. The mounted blades are excellent for preliminary work on rougher surfaces; you'll get better finish results with the hand-held blade. The blades come in several sizes, from 2 x 3 to 6 x 7 inches. Choose the size best suited to your work.

Scrape with the grain, never across, and work over the entire surface, covering small areas at a time. Repeat several times until the wood has a smooth, even, glassy feel.

Sanding. When you are through scraping, the wood is ready for sanding. Begin with a fairly fine grit (100 to 120 grit should be coarse enough), since a rough grit would scratch the surface. Do the preliminary sanding by hand. Wrap the abrasive around either a commercial rubber pad or a flat piece of wood.

If you use a wood block, place a pad of soft paper between the the block and the wood, to give a little flexibility to the cutting surface of the abrasive. The softness, slight as it is, will work better over the few high spots which still exist. A small piece of paper toweling folded two or three times will give you just the pad required.

Sand with the grain, covering small areas on each pass, working the full surface evenly



Top, scraper in handle, for preliminary work. Center, utility scraper for surfacing, paint removal. Bottom, cabinet scraper.

If a wood is not mill-planed it must be surfaced at home. The job can be done on jointer or planer or with hand plane.

each time. Repeat two or three times, then change to a finer grit. When you move up to a finer grit, discard the towel padding. If you use a flat block on these final stages, you'll get a flatter surface.

Move progressively to finer grits. Don't jump from the relatively rough 100 grit to a very fine one. Make the transition slowly. If you started with 100 grit, for example, move to 120, then to 150. If you prefer, these stages can be handled with an orbital or straight-line sander. These stages can be done by hand or power and its impossible to tell the results apart.

Be sure to remove the wood dust often and thoroughly. Either blow it off the surface or remove it with a brush. Don't use cloth; most cloths leave a lint that's nearly as troublesome as the dust. Check the abrasive paper often. The dust will collect in the open areas between the abrasive and when the paper is clogged, either clean it by hitting the paper against your clothing or replace the paper.

As you move to the finer grits—about 180 on—start raising the softer grains of the wood. This is best done by wiping the wood with a sponge *dipped* (not saturated) in water. A little moisture goes a long way; the idea is to bring the softer grains upward, raising or swelling the fibers above the surface of the harder grains. Here, they can be cut down by the abrasive. The result is a surface smoother than you imagined possible by any other system.

On most woods, the softer fibers are tough enough to stand erect like whiskers after they've been raised with water, but on some woods—mahogany is one—the fibers may bend under the force of the abraisive. You can keep them erect during sanding by

▲ *Mounted scraper blade is handy for early surfacing stages. Blade depth and angle are regulated by knurled screws.*

➤ *Scraper blade helps level and smooth wood prior to sanding. Scraper can be pushed or pulled, with blade angled.*

Preparing a new surface for stain. This sander has a foam rubber pad, backing the sandpaper.

When using a wooden sanding block, pad the sandpaper with paper towel to help the abrasive cut down high areas faster.

adding a little household glue to the water. When the glue hardens it will keep the fibers upright while you sand and if you don't overdo the glue, it will not interfere with the grain pattern.

Raise the grain several times, each time sanding the fibers back to the harder areas. Repeat this as you move to even finer grits. Continue until the soft fibers no longer raise above the sanded surface. On most woods it will take four to six passes with water and abrasive; a few woods may require as many as ten or twelve wettings. But be patient. This is an important step.

Continue to work your way through the grits until you get the finest available—generally a 320 grit available most frequently in a wet or dry paper. Use this dry.

The end grain is as important as the top and side surfaces and it should be sanded with the same care. But since the end grain is generally harder, it rarely needs to have the grain raised. You can usually work this dry all the way through.

There is a very real danger of splitting when you sand the end grain. The job will be easier and safer if you will clamp two straight-edged boards top and bottom across the end grain, and add two smaller blocks on the edges. This four-sided protection will prevent splitting and will give you a guide to keep the ends from being rounded as you sand.

The sanding is relatively easy since most surfaces are flat, but here are a few tips for those hard-to-reach areas.

Crevices and routed areas can be sanded best with unbacked paper bent to fit the depression. The paper will bend easier if

you'll pull it, abrasive up, across the edge of a table two or three times. Pre-bending will prevent the paper from cracking.

Try wrapping the paper around a sharpened stick when you must sand a groove or a rounded corner. Fold the paper over the end of the stick and use the finer point to reach into the smaller grooves.

Don't try to sand a large area down to smooth a small dent. It's generally easier to raise the fibers in the dent by carefully dropping water into the depression. An eye dropper is excellent for small areas. But be exact. If you drop water on the surrounding high areas well as into the low spot, you are not altering the relative depths at all. Stubborn dents which refuse to raise with repeated soakings can often be raised by heat and moisture. Place a damp cloth over the dent and heat it gently. A hand iron works well on larger areas; a soldering gun is perfect for small spots.

Final preparations. Once you've finished sanding with abrasives, polish or rub down the wood with two or three grades of steel wool before you apply a stain or a finish. Start with a fine (0C0) wool and finish with at least a 00000. The gentle polishing will further smooth the surface and will unlock the subtle tonal varitions in the grains you'd miss otherwise.

Be sure to remove all dust, abrasive and steel wool from the wood before you apply stain or shellac. You can remove most of the dust with a brush or paper towel, but if you use toweling be careful of lint. Some paper products can leave nearly as much lint as sandpaper leaves wood dust. Continue to clean the surface until it's completely clean. Do not use water—water at this point would still raise the grain just enough to require another round of sanding.

The wood should be completely clean, free of oil, dirt and dust before you finish with stain, varnish or shellac. And when you finish, be sure to use materials which enhance the grains you've uncovered. Not all finishes do this, so pick the right kind. At this point you've brought out all the beauty the wood has to offer. Don't waste it. B.B.

See also: ABRASIVES; CABINETS.

Dust wood frequently during the sanding. Use a brush or compressed air, but avoid fabrics, which may leave troublesome lint.

For a smooth surface, raise wood grain several times with water, gently dampening with sponge. Let dry, sand away fibers.

How to Stain and Finish Fine Wood

If you're using the best wood, use these techniques to give it the fine finish it deserves

TOO OFTEN, and in too many places, beautiful pieces of rare woods have lost their exciting identity, with grains suppressed by sullen, opaque stains. It's an easy way to finish wood, but it's not the right way. It is not even tasteful.

Properly finished, the grain of wood becomes an integral part of the furniture, and not every length of wood is worth the time and effort. If the wood you are working with is not worth the trouble, paint it or hide it with cheap stain. But if the wood is rare and the grain exciting, do the job right —let the grain shine through.

There are more ways to hide grain than to bring it out. You can find plenty of pigmented stains, colored varnishes and tinted shellacs. None of these has any important place in furniture finishing. All hide or obscure the grain.

Pigmented stains are the worst offenders. They're compounded with opaque materials which work harder to kill the luster and depth of wood than they do to beautify it. They're helpful in only one case: when it is necessary to fake a grain.

If you want to use these stains, try this idea. Avoid mixing the colorless liquid which rises to the top of the can with the heavier pigments which sink to the bottom. Instead, lift the liquid from the top without mixing. The color is fairly weak, but it works nicely when a light effect is needed.

Oil stains. Stains can deliver excellent results if you'll take the time to find the clear oil types. In many stores you'll find them under the name "penetrating oil stain." These can be used to tone wood to any shade or color without affecting the grain patterns.

Wipe on a liberal amount of the stain, let it penetrate into the wood a few seconds, then wipe it off. The longer the stain is left on, the less you remove; the more coats applied, the darker the effect. For light tones, dilute the stain with turpentine or a substi-

Clear oil stains give good tonal qualities without obscuring the fine grain.

Oil stain is allowed to penetrate pores; then it is wiped off evenly with a clean rag.

tute (it doesn't matter which). Be sure to put a good primer coat over the stain. Shellac is a good material, but if you prefer a commercial sealer use a clear one. The primer-sealer serves one function: It gives a surface on which you can build up the final, smooth finish coats.

Clear and penetrating oil stains are available in many tones and shades, but if you buy three—walnut, maple and mahogany—you have enough to mix to any tone you may need.

Certain of the better "prepared stains" are worth trying on some woods. One is a nearly clear stain with added plastic compounds which build up a smooth, tough surface. The oil colors the wood only slightly; it is clear enought to let the beauty of the grain come through. On lighter woods, the stain has a slightly yellow coloring—something you may or may not like. On darker woods it's hard to beat.

Aniline dyes darken the wood without affecting the grain. They are available as water-soluble or alcohol-soluble materials. You buy them as a dry powder, mixing a small amount with the proper liquid. Anilines are strong and one or two ounces will handle several large pieces of furniture.

Water-soluble anilines are applied directly to the unprimed wood. Most woods have distinct areas of "dense" grain and "porous" grain—layers grown in the spring and summer and in the fall and winter. The faster-growing spring and summer layers are the most porous. They absorb more color and the fibers can lift. The water-soluble dyes raise these fibers and you'll have to resand the wood after the stain dries even if you've raised the grain several times during sanding.

Resanding is safe and easy if you'll apply a thin coat of shellac after the stain has dried. The shellac will hold the fibers erect. You can smooth the surface without working into the stain—if you sand lightly with

a very fine abrasive paper or with steel wool. A 000 or 00000 steel wool is preferred.

Chances are you will have to resand even when you prime-coat wood without staining. A brush drawn over wood pulls up tiny fibrils. The primer holds these erect as it dries. The result is a rough surface which can be smoothed by a few light rubs with steel wool. Be sure to thoroughly clean the surface before adding another coat.

Alcohol-soluble stains seldom raise the grain and, if they do, have less effect than a water stain. They can be used over raw wood or mixed with shellac or varnish.

Although anilines are available in a host of colors, you will need only a few. Buy three: walnut, mahogany and maple. From these you can mix any color for any wood.

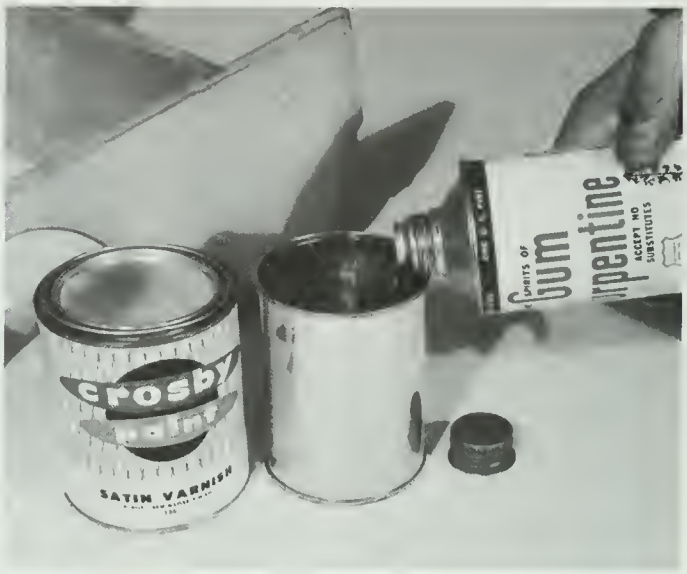
An example: If you want a mahogany brown, add a small amount of walnut to the maple stain. The result is a rich mahogany stain you can't buy ready-mixed. Want a dark cherry stain? Add a little maple to a mahogany base. For a lighter cherry, add a little mahogany to a maple-walnut base.

Shellac is an excellent primer or finish coat. It should be thinned only with a wood alcohol.

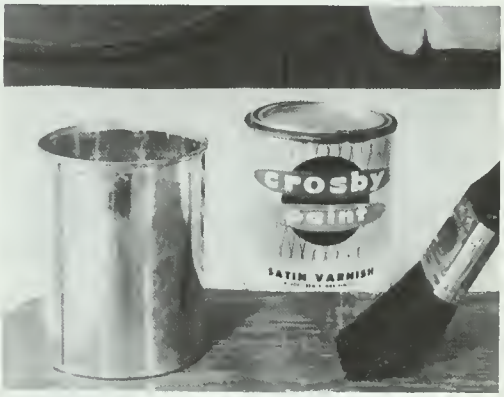
It is brushed on, allowed to dry, then sanded lightly before the second coat is applied.

Some stains contain plastic compounds. These require no other surface care.

➤ *Varnish is a tough, durable finish coat. Use turpentine or a good substitute to thin.*



➤ *It is applied with a brush, thoroughly dried, rubbed with fine steel wool, and waxed.*



Faking wood grains. Some woods are nearly uninteresting in their own grains but become much more interesting when they are stained to look like another wood. The New England whitewood or tulip poplar is one example. It is much more exciting when it has been stained to simulate cherry, mahogany or even birch or cedar.

Here, pigmented stains are helpful. A clear stain can change the grain coloring, but it does not obscure the grain pattern—the one thing necessary in this case. Pigmented stains not only color the wood, but help hide the grain.

In some cases even the opaque pigments may not alter the grain enough. A thinned wood filler may be just what you need.

Mix a standard wood filler—white is best—with turpentine to make a smooth, not-too-thin paste. Tint the paste with stains to the color you want and spread the filler over the wood surface. Wipe off the filler. The amount you leave on the wood will control the amount of grain showing through. A little experimentation will let you simulate both the color and the grain of many woods this way.

Finishing the surface. The type and the amount of stain are dictated by the wood, its coloring and its grain. In some cases no stain at all is dictated. What is required is a simple, protective finish that gives good depth and luster. Early cabinetmakers found the answer in the French polishing method, which can be used on either raw wood or stained wood. It is not often used today, but works well and can be worth the time required.

Use white or clear shellac, about 3- or 4-pound cut (which means that 3 or 4 pounds of shellac gum have been dissolved in one gallon of alcohol). Thin the shellac with wood alcohol and brush it onto the

Older rubbing techniques use pumice and then rottenstone; steel wool gives equal results.

wood, rubbing the wet shellac into the wood after brushing.

Use a rubbing pad made by placing a wadding of cotton inside a soft cotton cloth. Pick up a little linseed oil on the bottom of the pad (the oil is used only as a lubricant during rubbing). Rub the shellac uniformly before it dries. Repeat the brushing and rubbing process 6 to 12 times, making each pass with more shellac and less thinner. Some finishers prefer to make the first coats with a one pound cut, increasing the mix by moving to increased shellac-cut percentages, finishing the final coats with 3- or 4-pound cut shellac. After the first two

The shellac is then rubbed with a pad dipped in linseed oil until shellac is dry and has a smooth surface.

In the French method, thinned shellac is brushed into the surface.

coats are on and dry, you should sand between each additional coat with a fine grit paper or with fine steel wool.

A plain shellac finish has many uses. It's easier than the French system and gives comparable results. Again, use clear shellac, thinning it with three or more parts wood alcohol. Brush on each coat of shellac, sanding with abrasive or steel wool after the coat has dried. Cover with three to five light coats, then polish.

Be sure each coat has dried thoroughly before you sand. It may be an overnight procedure. When the finishes are on and rubbed, polish with a good wax.

On warm days you may find the shellac is dry enough to sand in 3 or 4 hours. On humid days, the alcohol in the shellac may draw moisture from the air, creating a white film on the surface. The only solution is to remove the shellac with wood alcohol and start again when there's less humidity.

Varnish is absolutely essential if the wood is to be used around hot plates or moisture or if it is to get table-top treatment. It's best to prime the wood with two or three coats of thinned shellac, although a commercial sealer will work as well. Let the primer or sealer coat dry, then rub it lightly with 000 steel wool. Clean the surface with a brush and cover with a layer of quality synthetic varnish. The synthetic varnishes dry faster and give a better surface.

Use a new brush for each varnish job. You'll get best results if you'll varnish with cheap brushes; better than if you've used a good brush which has been cleaned several times. Don't try to save varnish—it is seldom as good the second time around.

When you varnish, try thinning with equal amounts of turpentine or turpentine substitute if it seems hard-flowing. A thinner varnish is less apt to show brush marks. Another trick, often better than thinning is to heat the varnish. Heated varnish will flow easily and dry faster.

Linseed oil finishes are becoming popular again, after a hiatus of many years. Avoid the true linseed oil finish as you would pigmented stains. Such a finish collects dirt as it is applied, and from then on. The result is a grimy finish that is both without luster and without grain. A far better answer is the *fake linseed oil* finish several wood finishers use.

Coat the raw wood with a mixture of varnish thinned with 2 or 3 parts turpentine. Rub the mix into the wood with your hand, working vigorously for 3 to 5 minutes, until you feel your hand become hot and the varnish become tacky. Wipe off the excess with a clean dry cloth. Let the coat dry, then sand lightly with 00000 or 000000 steel wool. Apply two or three additional coats of varnish, sanding between each coat.

Let the final coat dry thoroughly then sand again lightly. Brush linseed oil over the varnished surface, covering areas not varnished for extra protection. Let the oil soak into the surface for 12 to 15 minutes, then rub clean with a dry cloth. The result is a finish that is clean and durable and that looks like a real linseed oil finish but lacks its obvious drawbacks.

Conditioning finishes. All finishes except the "fake linseed oil" finish can be protected with wax. The linseed oil should not be waxed, but it can be brought back to life from time to time by removing the oil surface and re-surfacing with another round of oil.

The other finishes should be well sanded with super-fine steel wool (0000 or finer), then covered with a good furniture polish or wax. The final result is a finish that has more luster, more depth, more patina than any finish you can get through short-cut methods. And beneath the finish you can see the beautiful, rich, natural grain of the wood. That's the right way to finish wood. It's well worth the time and trouble. B.B.

See also: ABRASIVES; CABINETS.

Repair and Maintenance of Your Fireplace

If your fireplace is working properly, it does not smoke, lose heat or choke the fire. By following these guides, you can make your fireplace give you 100 percent warmth

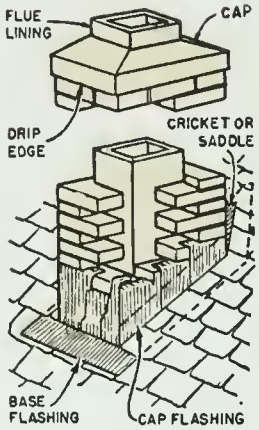
CHILLY EVENINGS always call for a warm fire in your fireplace. But suppose the crackling flames puff out smoke to mess up your walls—or a fire is hard to start and keep burning. Why not fix your chimney and fireplace so you can enjoy its comforting warmth while winter winds whistle outside—and know leaky cracks in the chimney cannot start a fire or let too much heat go roaring up the chimney.

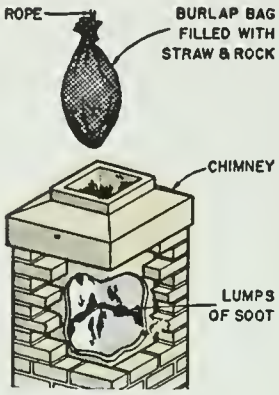
The simplest prescription for curing a smoky fireplace is a good cleaning—not only the floor but the wind shelf up and inside the throat—an easier job if you remove the damper, a metal door covering the throat. Unhook the damper control rod by unscrewing it or pulling the cotter pin, and lift out the damper. Using a scraper, or a piece of sheet metal bent like a garden hoe, clean away any soot around the damper seat and from the wind shelf above the damper. This wind shelf and damper deflect the wind gusts that whistle down the chimney and shoot them back up again. But if the shelf is caked with soot, the wind pattern is disturbed and the gusts blow smoke back into the room.

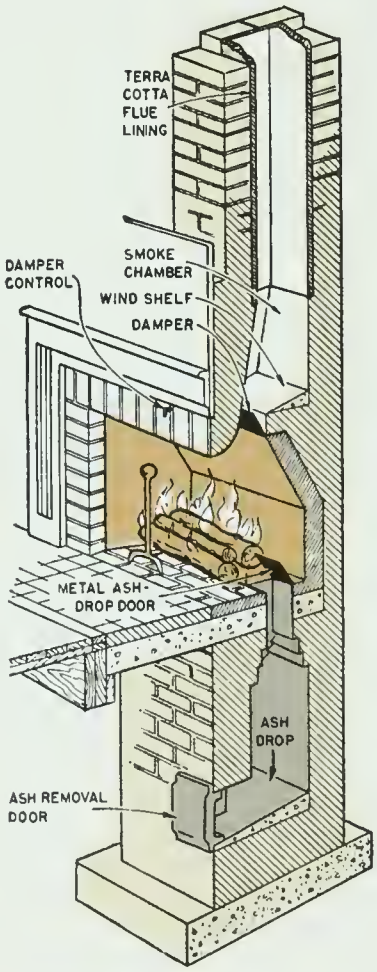
Before cleaning the walls and floor of the fireplace, dampen the ashes and soot with a garden sprayer. Sweep the bulk of the ashes into a paper back and finish the job with a vacuum cleaner. If your fireplace has an ash removal door, sweep this dirt down the trap and shovel it out from the basement ash drop.

When you reinstall the damper, make sure it fits tightly around its opening and adjust the control rod for maximum opening if there is a screw adjustment. If your damper should be badly cracked, broken

fireplace, decorative: see tile, ceramic
firewood: see campfires







or warped, replace the old one with a purchased duplicate or one made to fit by your local blacksmith or sheet metal shop. If the damper is slightly warped, you may file or grind down the edges to fit or weld on thin strips to fill wide cracks.

Suppose, after all this cleaning, your fireplace still smokes. The next step is to look down the chimney from the top with a flashlight or up through the throat with a mirror. Be on the lookout for clumps of soot, cracks or breaks in the flue lining, loose pieces of flue tile, or branches and debris that may have blown or fallen into the chimney.

To remove soot from a chimney flue, weight a burlap bag with several stones and partly fill it with straw, excelsior or old rags and drag it up and down the chimney flue. During this cleaning, cover the fireplace opening with a damp cloth hung from the mantle.

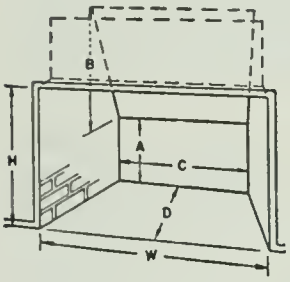
Since dragging a bag up and down runs into a lot of work you probably want to know about chemical soot removers. The facts are that chemical soot removers are dangerous to use and Underwriters Laboratories, Inc., have not approved any of these soot-burners. Chemicals can set clumps of soot afire in the chimney that burn furiously and open or burn through cracks in the chimney or blow out the top to land on a roof—still burning. Salt is an old

chemical treatment, but the gases generated in burning salt on a hot fire are dangerous and may set the soot in the chimney afire. Burning a Christmas tree in a fireplace can set soot in the chimney to burning too.

If your flashlight examination showed a loose chunk of masonry or debris blocking the flue, you may be able to dislodge the obstruction with a long bamboo fishing pole, lengths of pipe screwed together or a plumber's snake. For safety's sake, tie a cord to the end of the pole so you won't lose it down the chimney, and place a board on the hearth floor to keep any chunks of dislodged masonry from breaking the firebrick. If you are working up from the bottom, wear goggles of some kind to protect your eyes.

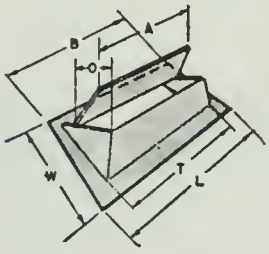
When you finish cleaning your fireplace and chimney and your fireplace still smokes, check the draft by opening a window to supply plenty of air. If it still smokes with plenty of air, the trouble may lie in the height or position of your chimney. Check the chimney's height. Topping the trees or building up the chimney height of one that is too low will help, but a better solution is to build a cap on top of the chimney.

A stone or concrete chimney top open on all four sides is about the simplest to build. The area of the openings around the side should total four times the cross section area of the flue. Rotating metal cones or turbine top caps are available from mail order houses or at your local



FIREPLACE DIMENSIONS

Opening		Depth,	Minimum back (horizontal)	Vertical back wall	Inclined back wall,	Outside dimensions of standard rectangular flue lining	Inside diameter of standard round flue lining
Width, W	Height, H	D	C	A	B		
Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
24	24	16-18	14	14	18	8½ by 8½	10
28	24	16-18	14	14	18	8½ by 8½	10
24	28	16-18	14	14	20	8½ by 8½	10
30	28	16-18	18	14	20	8½ by 13	10
36	28	16-18	22	14	20	8½ by 13	12
42	28	16-18	28	14	20	8½ by 18	12
38	32	18-20	20	14	24	8½ by 18	12
42	32	18-20	28	14	24	13 by 13	12
48	32	18-20	32	14	24	13 by 13	15
42	38	18-20	26	14	28	13 by 13	15
48	38	18-20	32	14	28	13 by 18	15
54	38	18-20	36	14	28	13 by 18	16
60	38	18-20	44	14	28	13 by 18	15
42	40	20-22	24	17	29	13 by 13	15
48	40	20-22	30	17	29	13 by 18	15
54	40	20-22	38	17	29	13 by 18	15
60	40	20-22	42	17	28	18 by 18	18
68	40	20-22	48	17	29	18 by 18	18
72	40	22-28	51	17	29	18 by 18	18



DAMPER DIMENSIONS

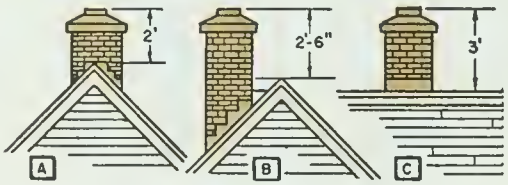
Throat			Overall		
Bottom T	Top A	Opening O	Length L	Back B	Width W
24	17 5/16	4 1/4	28 1/2	21	9 7/8
30	23 5/16	4 1/4	34 1/2	27	9 7/8
33	26 5/16	4 1/4	37 1/2	30	9 7/8
38	29 5/16	4 1/4	40 1/2	33	9 7/8
42	35 5/16	4 1/4	46 1/2	38	9 7/8
48	41 5/16	4 1/4	52 1/2	45	9 7/8
54	42 1/2	7	68 1/2	48	14 5/8
60	49 1/2	7	64 1/2	53	14 5/8
72	60 1/2	7	76 1/2	64	14 5/8
*84	73 1/2	7	88 1/2	77	14 5/8
*96	85 3/4	7	100 1/2	89	14 5/8

*Two Valve Plates.

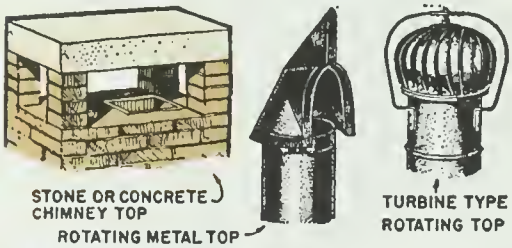
sheet metal shop and are generally more effective than a simple stone or masonry cap.

Two or more flues in the same chimney sometimes cause trouble when smoke from one flue is sucked down into the flue alongside. If you notice this happening with your chimney, change the height on one or more flues so that all are at different elevations. If this does not cure the trouble, erect a brick wall between the flues or cap the flues with separate caps.

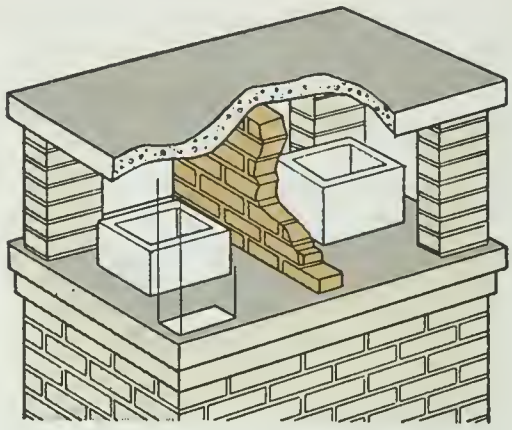
Another cause of poor draft may be the size of your fireplace opening relative to the area of the flue. A flue that is too small cannot provide the necessary draft to keep a fire burning and smoke from drifting out into the room. Two solutions are possible for a small flue. Install a blower in the flue to force a draft up the chimney and make up for the small area. Since each chimney is an individual problem and blower fans require tricky installation to insure proper operation, you'd best call in a heating and chimney man. Or you can reduce the size of the fireplace opening so the flue is no longer overloaded. With a fire burning in the hearth hold a board



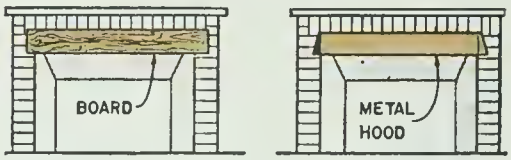
Proper height of chimney opening above roof line for draft. Chimney on centerline (A) and away from (B) pitched roof line. (C) Flat roof.



Chimney caps to control downdrafts from surrounding trees and high buildings.

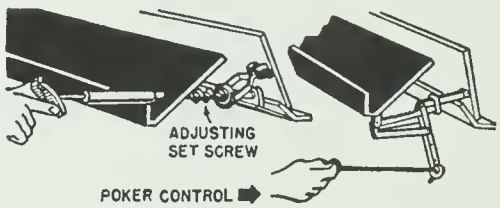


Building a low wall between flues can stop one from drawing smoke from the other. Corner blocks help to induce draft.



across the face of the fireplace and, while sliding the board up and down, notice if the draft is improved. When you find the opening that produces the best draft, mark it and either build a metal hood to lower the opening or add a row or two of firebrick under the top or to the hearth floor. Added firebricks on sidewalls will help to reduce the size of an overly large opening.

Cracks and leaks in mortar joints not only interfere with draft, but are a definite fire hazard. One way to spot chimney leaks is to build a smoky fire in the hearth with straw or bits of tar paper. Open all the windows in the room and set a large fan



Mortar between firebrick eventually disintegrates, and should be replaced in time to avoid possible shifting of the brick. Use a pointed trowel to tamp the mortar into the crevices.

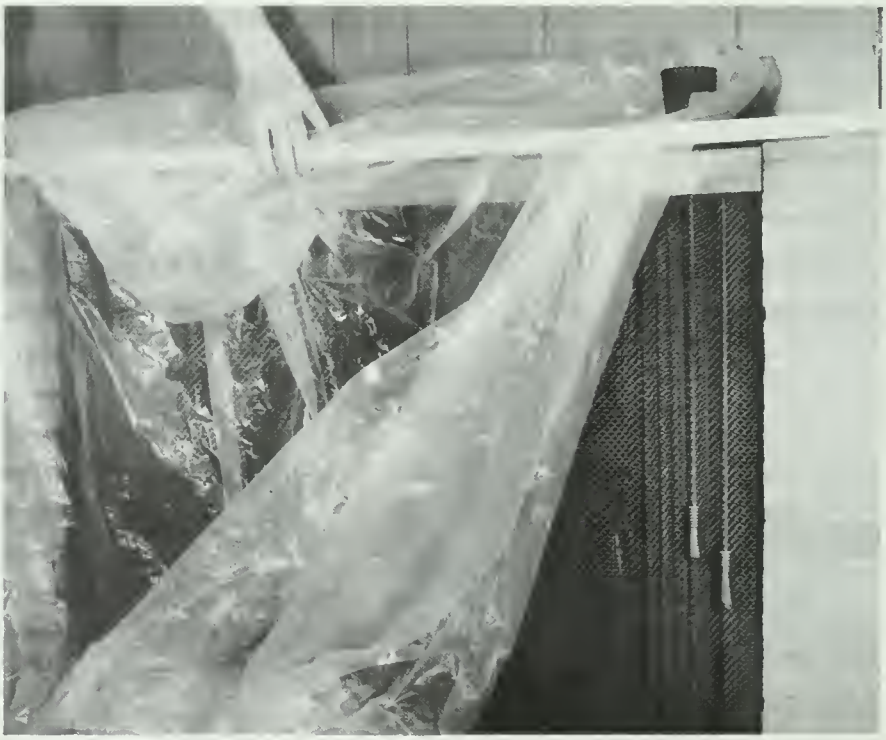
blowing into the fireplace to build up a draft. When dense smoke is rising through the chimney, cover the top with a wet blanket and check over the entire fireplace and chimney length. Smoke will work its way through the cracks and leaks.

Leaky mortar joints, crumbly mortar and cracked bricks should be filled with fresh mortar. First remove all old and loose mortar with an ice pick or sharp screw driver and brush with a stiff wire bristle brush. Wet the joints before packing them full with a mortar mix of one part cement to three parts sand. Use only enough water to make a fairly stiff mix—about like cake dough. If any firebricks in the hearth or sidewalls are loose, remove the brick and chip out the old mortar. Replace the firebrick using furnace cement mortar or fire clay (available at hardware stores) mixed to spread evenly. If furnace cement or fire clay is not available, mix a mortar of one part lime and six parts sand. Butter the mortar across the back and all four sides before tapping in place with a mallet. Be sure to replace broken firebricks with firebrick only and let dry two to three weeks before building the first fire.

Water seeping into and around the fireplace can start cracks in the joints and damage wall areas. Check flashing around chimney at the roof and the caulking where the chimney meets wood or shingle sidewalls. Frost action or settling can open cracks in the chimney that leak smoke and let in water. Replace any cracked or crumbly caulking and tuckpoint the cracks in the masonry as noted above. If flashing is loose, bend the ends into the joints and pack in mortar or caulking compound to fasten it in tightly. Replace flashing that is thin or rusted through completely.

When you have got the fireplace so it burns without smoking, you will want to clean off smoke stains from the masonry. Mix 1½ pounds caustic soda (from hard-

When vacuuming the hearth, also remove soot from the chimney itself, as far as you can reach with the vacuum hose. Opening and closing the draft door will cause soot to fall.



When a more thorough chimney cleaning is required, you can reduce the amount of soot entering the house by covering the fireplace with a plastic drop cloth, as shown.

Ash collection box at base of the chimney is accessible through metal door, and should be emptied periodically. Because of the fly ash, use a vacuum cleaner rather than trying to scoop out the ash.

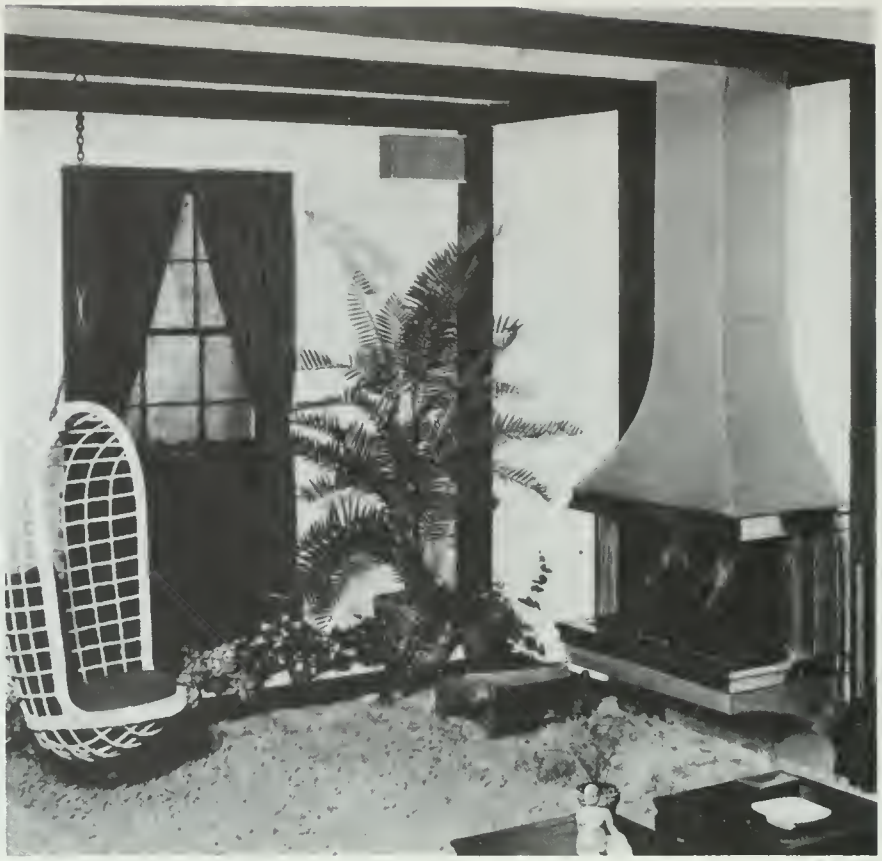
ware store) in one gallon of hot water. Apply this mix to the stained areas with a fiber scrubbing brush to clean off the stains —then rinse with two flushings of clear water. Be careful not to splash the caustic on any painted surfaces. If this mix does not take off the stains, try a muriatic acid solution (ten parts water to one part acid available at most paint or hardware stores). Do not mix the acid solution in a metal container, apply with a natural fiber brush and wear rubber gloves. Rinse off the acid solution at once with plenty of clear water.

Burning paper and trash in the fireplace will cause nearly any fireplace to smoke because the flue is not large enough to carry off the smoke that a heavy blaze from a load of paper produces. If you must burn trash and paper in your fireplace, start the fire first and feed in the fast burning material slowly so that you will be able to keep the blaze under control.

Building a fire is a cinch if you follow these directions: Lay logs long enough to lie across the andirons parallel to the back of the fireplace over crumpled paper or excelsior and kindling. Lay a large log at the back, a smaller one in front and a still smaller one on top of these two. Leave space between all the logs so the flames from the kindling will burn up around them to start them burning.

Light the paper under the kindling and then hold a burning piece of lighted newspaper in the fireplace throat to start a draft, or you can crumple paper on top of the logs to start a draft. When adding logs to a burning fire, always add them at the back. A bed of ashes deep enough so the top is 1 to 1½ inches below the logs helps to keep the fire burning and when you retire at night burning brands dropping into the ash bed are either extinguished or glow all night so that a few puffs from a bellows gets the fire started again in a hurry. R.S.

See also: CAULKING; CHIMNEYS.



Fireplaces, such as this prelabricated wall-hung unit, are inexpensive and easy to install compared with fireplaces built of masonry.

Add a Fireplace to Your Home

It's easier and less expensive than you might think. You can install a prefabricated unit in almost any room in a weekend

BRING THE CHARM and comfort of a wood-burning fireplace into any room in your house, without the high cost of conventional masonry construction. A manufactured fireplace can be erected in about 10 hours.

Modern styling and a variety of models make it possible to select a fireplace that can be in the family room, kitchen, den, bedroom, enclosed patio, and cabin. There are free-standing units that can even be moved to various locations in the room —as long as you provide several chimney outlets; and there are stationary types that can be put against a wall without making a special foundation for it.

The only tools required for the installation are a hammer, screwdriver, keyhole saw, hacksaw, tin snips, carpenter's level, and a ¼-inch drill. A few masonry tools will be needed if you install the fireplace in your basement and run the chimney through the foundation wall.

To assure efficient operation of the free-standing unit, the fireplace should be located as close to the chimney as is practical. Make the smokepipe connection to the chimney flue short and direct, using as few elbows as possible. Choose a location convenient to a window, or a position where the chimney can run through the interior

of the house or an outside wall. If the fireplace flue is to run through the interior of the house, you might consider locating it where it is possible to box in the chimney or run it through an interior closet. A space approximately 19 inches square is required to do this.

Be sure to connect the fireplace to a chimney flue not serving any other major appliance whenever possible. If the fireplace is connected to a flue serving other appliances, which may be operated while the fireplace is also in use, the flue must be of adequate capacity to handle the products of combustion of both appliances. By overloading the flue, there is a possibility that one appliance may interfere with the draft for the other and consequently result in a smoking problem.

Most building codes require that the back and sides of the free-standing fireplace be kept a certain distance from combustible materials, unless it has a high temperature insulation barrier built into it. Free-standing units are set 18 inches away from the wall.

It's recommended that the floor under the fireplace, 8 inches on each side, and 16 inches in front of the firebox opening be made of, or protected with, non-combustible material such as ceramic tile, asbestos tile, brick, or concrete.

For best operation, the smokepipe should not run horizontally for a distance exceeding one-half the vertical height of the chimney serving the fireplace. Do not connect the fireplace to a vent that is designed for use only with a gas-fired furnace or appliance such as a water heater. If the location you choose does not have an existing flue to serve the fireplace, a specially designed insulated chimney should be installed. This chimney has an outer casing around the smoke pipe that gives safe insulation protection when it is run through a partition, ceiling, or roof.

After you assemble the fireplace by following manufacturer's instructions, position it where you intend to make the complete installation. First step is to install a 2-foot length of smokepipe with a damper on top of the fireplace, and seat it firmly. Press together the other sections of the smoke pipe until you are near the ceiling.

At this time, measure the distance from the center of the smokepipe to the back wall and from another wall so you can determine the relative position of the fireplace in the room. Use these dimensions, once you are in the attic, to drill a guide hole between the rafters so that the chimney is accurately centered.

When you're back in the room, drill a starter hole and use a keyhole or saber saw to cut through the ceiling. The chimney starter section is designed so that it can be fastened to standard 16-inch rafters or joists by means of common nails or wood screws.

Extend the chimney through the roof so

A free-standing prefabricated fireplace.

A prefabricated fireplace incorporated in a room divider.

that it protrudes by at least 3 feet when it is located more than 10 feet from the peak, or 2 feet above the peak of the roof.

After the chimney is installed, carefully check to be sure that the flue collar of the fireplace is aligned with the chimney flue, and that the smokepipe is vertical. Cut the last section so that the end of the smokepipe will clear the upper part of the notch in the flue adapter by about ¼-inch. Rock the pipe forward and install the cut section. Push the pipe into the adapter and securely fasten the front cover strip to hold it in place.

When the smokepipe goes through an outside wall, the horizontal pipe should be pitched at least ¼-inch for every foot of flue used between the fireplace and the elbow. This way you can be assured that the smoke will flow upward and not become trapped in the outlet and cause a smoke problem.

A concrete base pad can be laid and a "T" section embedded in it when the chimney comes through the foundation wall in a basement installation, and has to travel a long way to get through the eave and above the roof. The 8x18x18-inch pad is made so that 4 inches of mortar is below the ground surface, and it is close enough to the house so it won't be disturbed by the frost. After the cement is poured, embed the "T" section in it and allow the mixture to set. Use excess mortar to seal the opening where the pipe passes through the foundation.

Set the chimney up in sections from the pad to the eave. Use a keyhole saw to make the 15-inch opening in the eave, and continue with the chimney until it reaches the required height. As the chimney is installed along the wall, hold it in place with metal straps that are placed around each section and screw-fasten to the wall. Fill the opening between the eave and chimney with roofing tar.

A conventional sheet metal chimney cannot be used because it does not have the insulating qualities necessary to provide for a zero clearance to combustible materials. Special prefabricated chimney sections have an inner flue and an external flue shield. Insulation material air space built into the sections provide heat barriers that are necessary when installing the chimney near combustible material.

The permanent fireplace can be installed against a finished wall surface, or it can be recessed into the wall not to exceed 3 inches, provided that any header or plate which is cut into is adequately reinforced. The chimney must rise vertically with no bends or offsets.

This fireplace is designed to fasten to studs located on 16-inch centers. When installed against a finished wall, fasten to the studs with ¼ x 2-inch lag screws, not just to the wall surface. If the studs are not on 16-inch centers or if the desired location is such that holes do not line up with the studs, mark the center line of the desired

Fire pit of this free-standing unit is open all the way around.

location on thc floor near the wall, and mark the wall so you can install the headers.

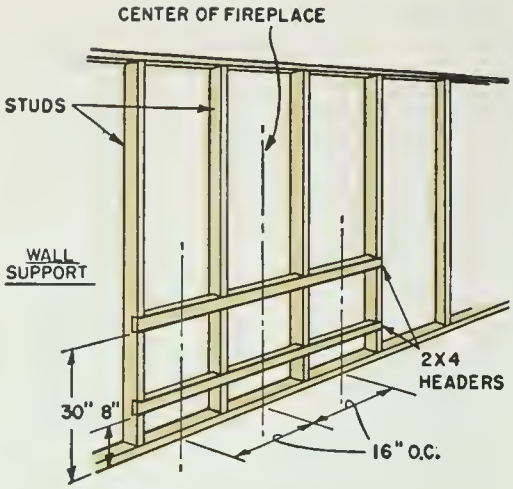
Assemble the fireplace according to manufacturer's instructions and make a 14½-inch square opening in the ceiling with your keyhole saw directly above the hood. Box in the opening to hold the flue in proper position against the wall.

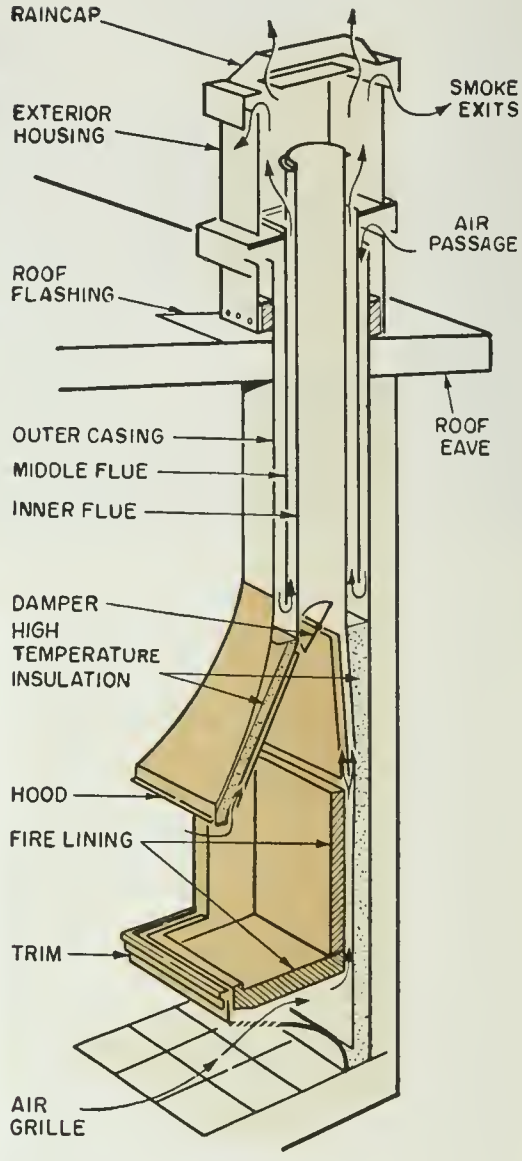
All joints in the chimney sections should be tight and smooth. After setting each section in place, tap each corner with a wooden block to close any gaps and to align the moldings. This ensures tight joints at all corners.

For most chimney installations the middle and inner flues should extend no higher than the peak of the roof and not less than 7 inches below it. Occasionally, when the chimney exit point is less than 12 inches measured vertically from the peak, the flues must extend 7 inches above the roof at point of exit. If necessary, cut off the excess. Toenail a box of 2x4s on edge around the opening in the roof, and flash around this box.

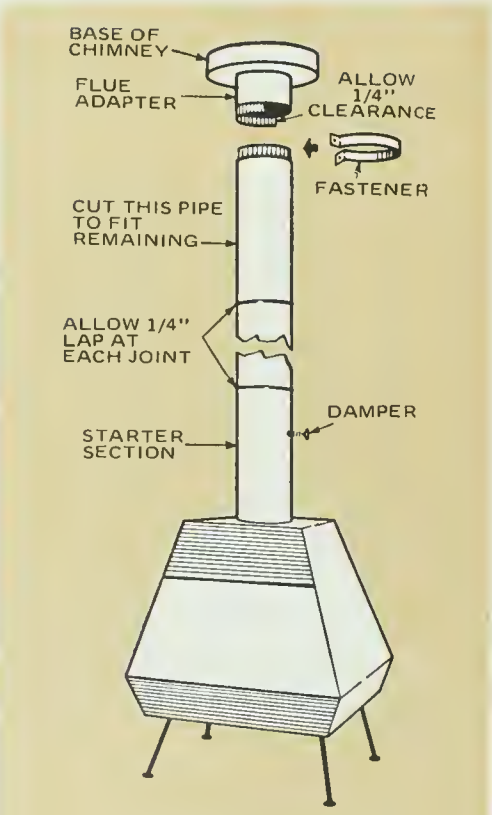
Cut the lower part of the chimney housing to the pitch of the roof and to the proper height. The top of the housing should be at least 12 inches above the point where the housing comes through the roof. Set the housing over the 2x4 roof box, plumb and nail securely to the box. Apply caulking where the housing meets the roofing.

Free-standing fireplace designed for installation in a corner.





PERMANENT INSTALLATION



FREE-STANDING UNIT

These packaged fireplaces are available in many enamel finish colors to suit your room decor. Some models can be painted with either a flat or enamel paint when you change your color scheme. Many of the units come already primed from the factory.

A.M.

See also: HEATING SYSTEMS, HOME.